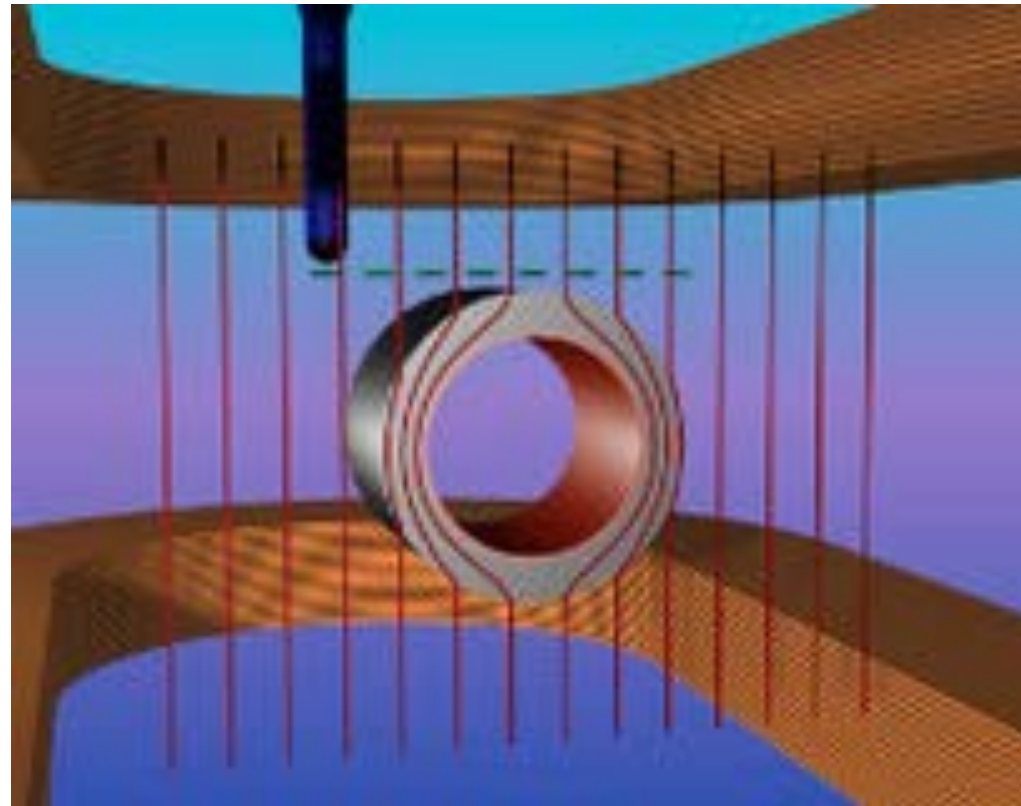




Stony Brook University



# Magnetic Field Cloaking Device

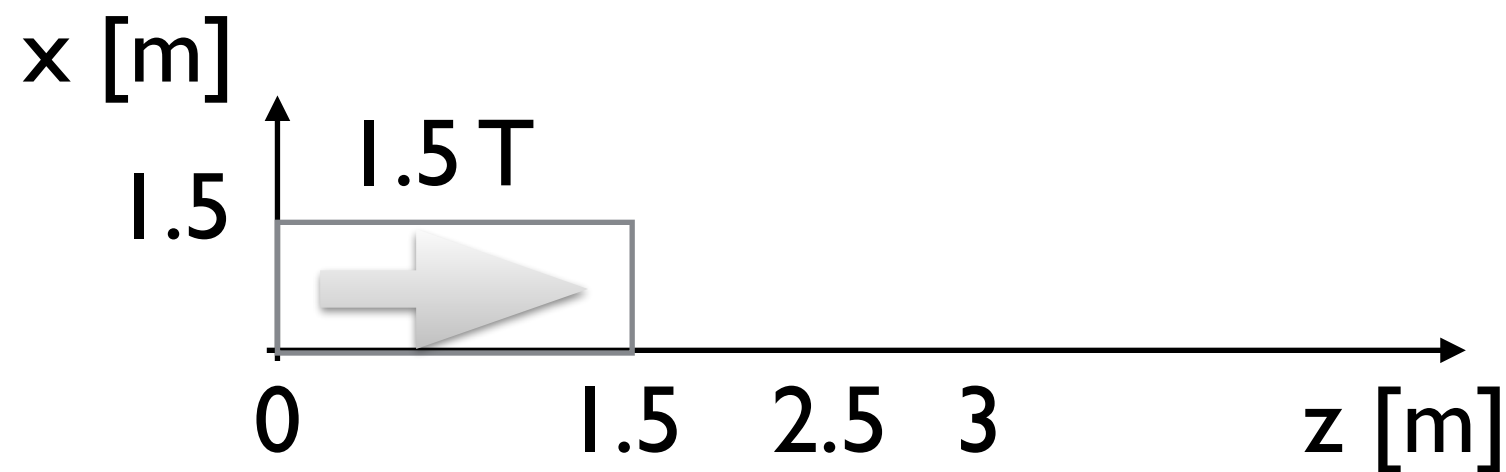
## eRD2 Progress Report

Abhay Deshpande, Nils Feege

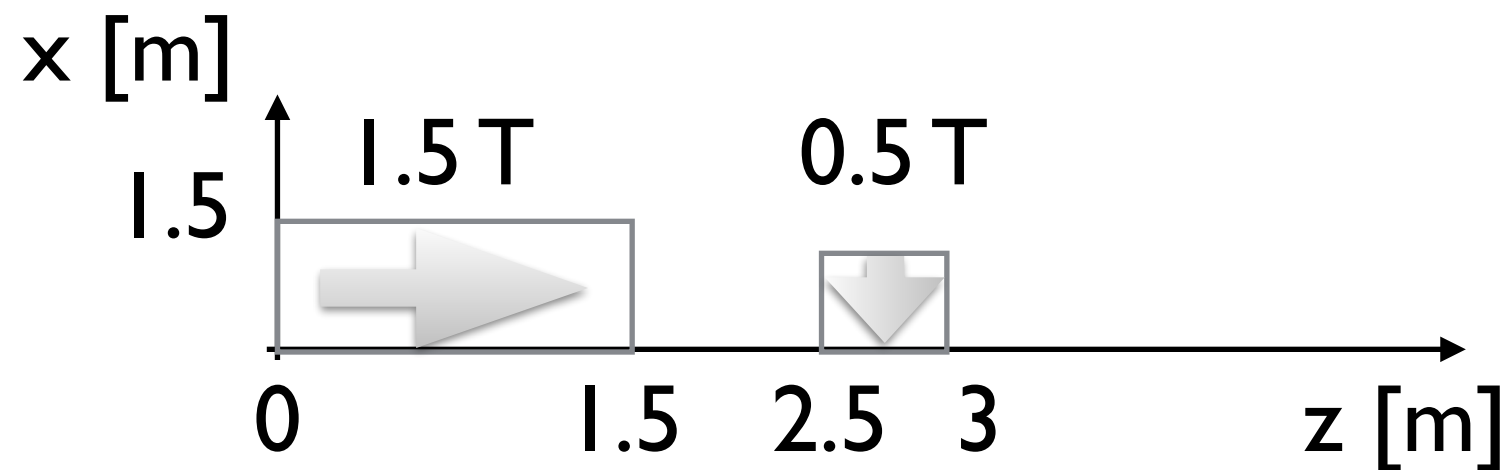
EIC Advisory Committee Meeting; BNL, January 22, 2015

# Charged Particle Tracking in 'Forward' Direction: Simplified Magnetic Fields

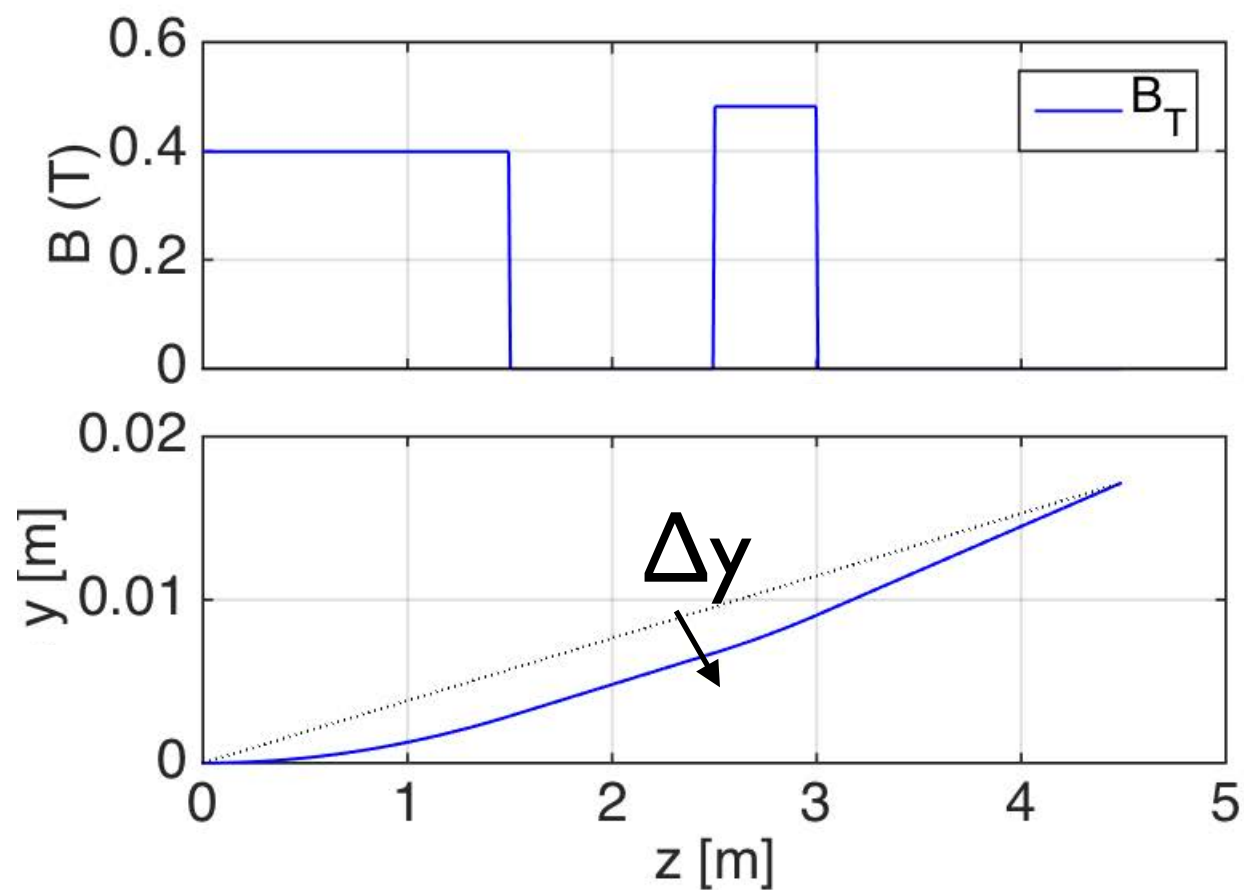
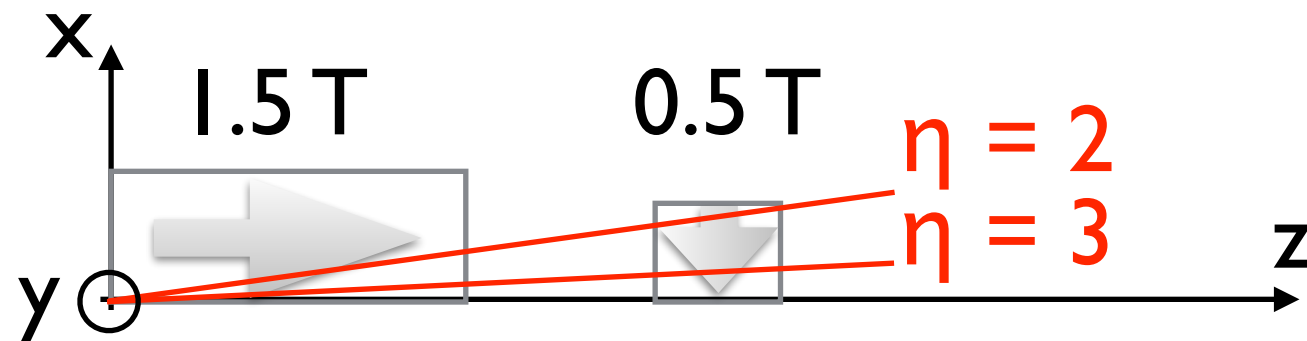
Solenoid



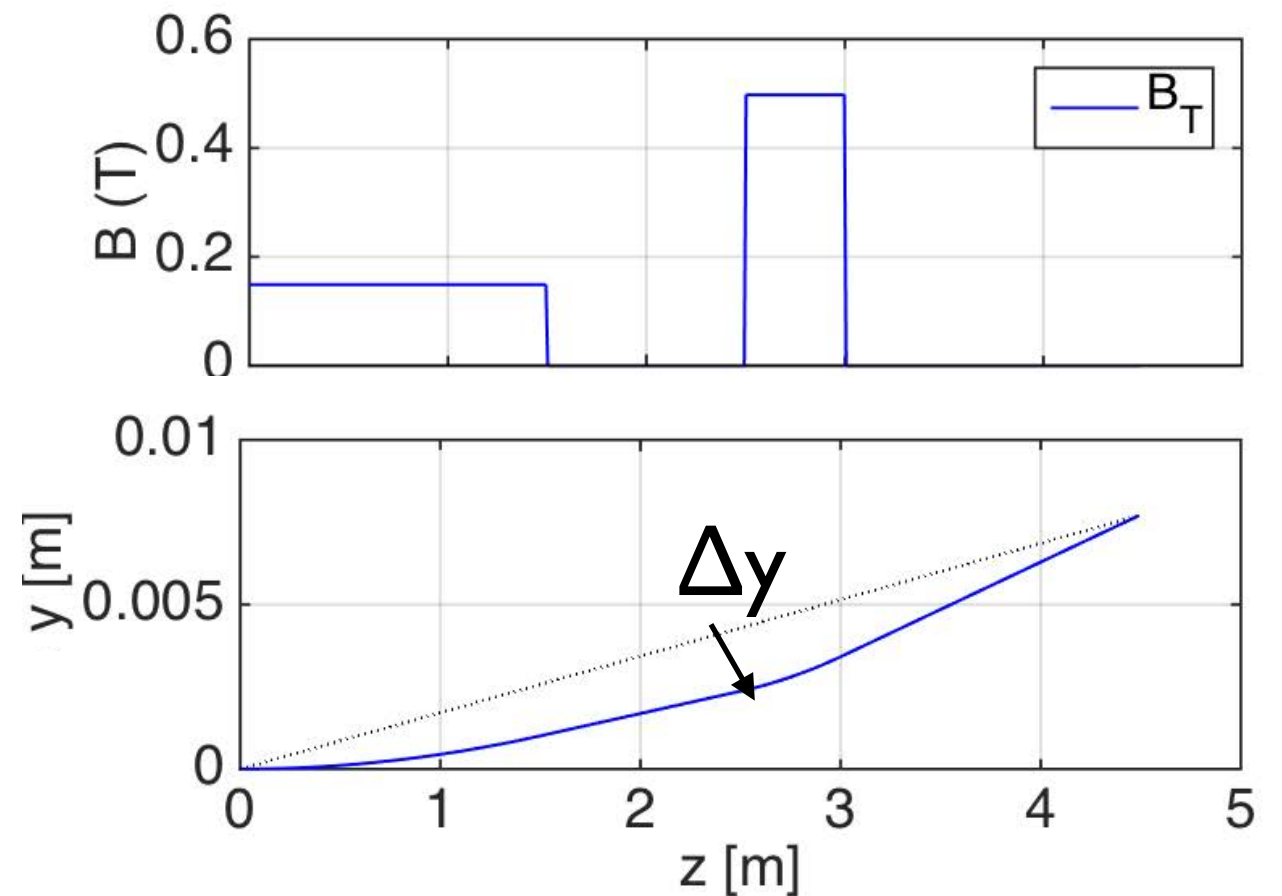
Solenoid  
+ Dipole



# Example: Bending 50 GeV Particles

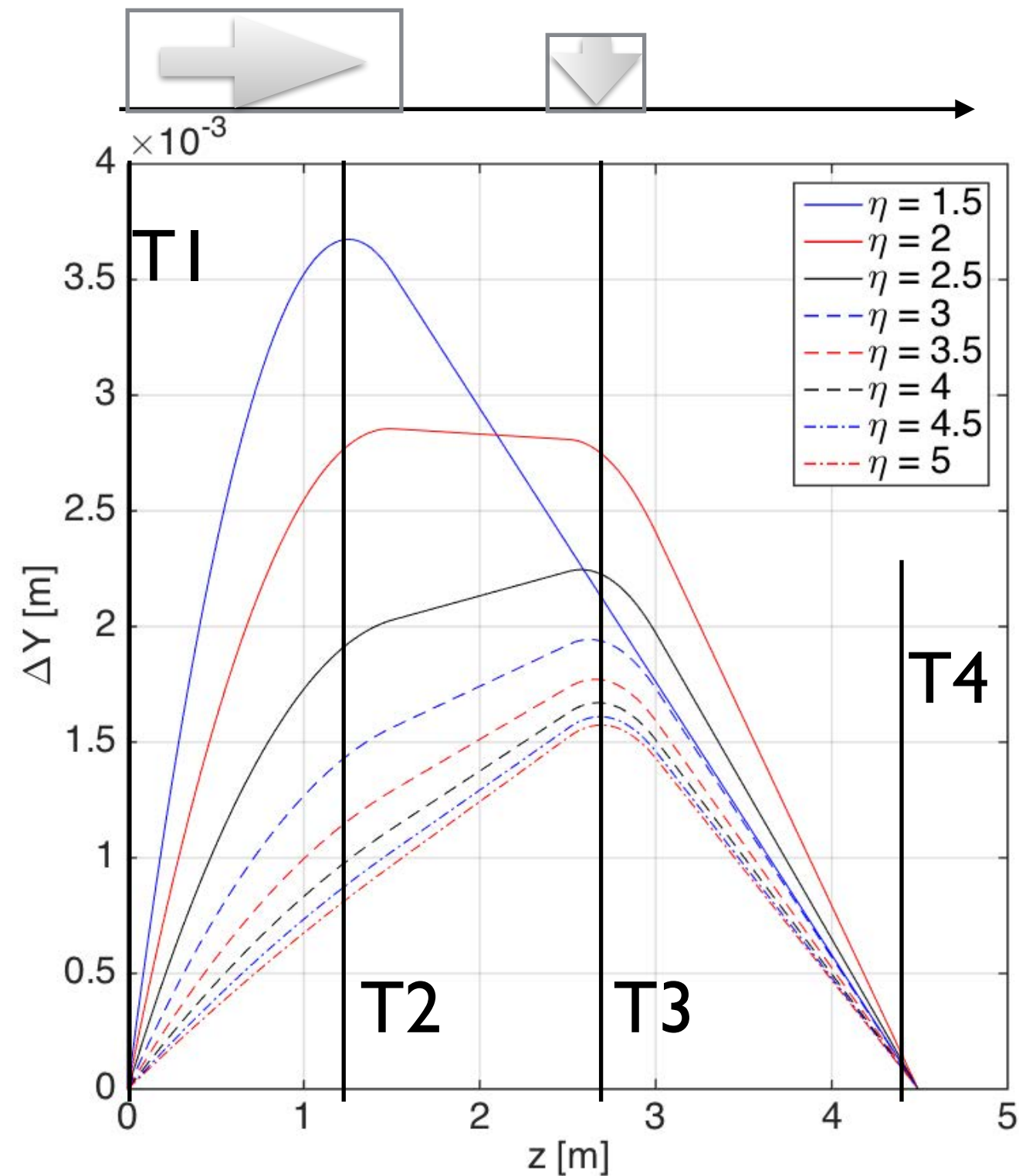
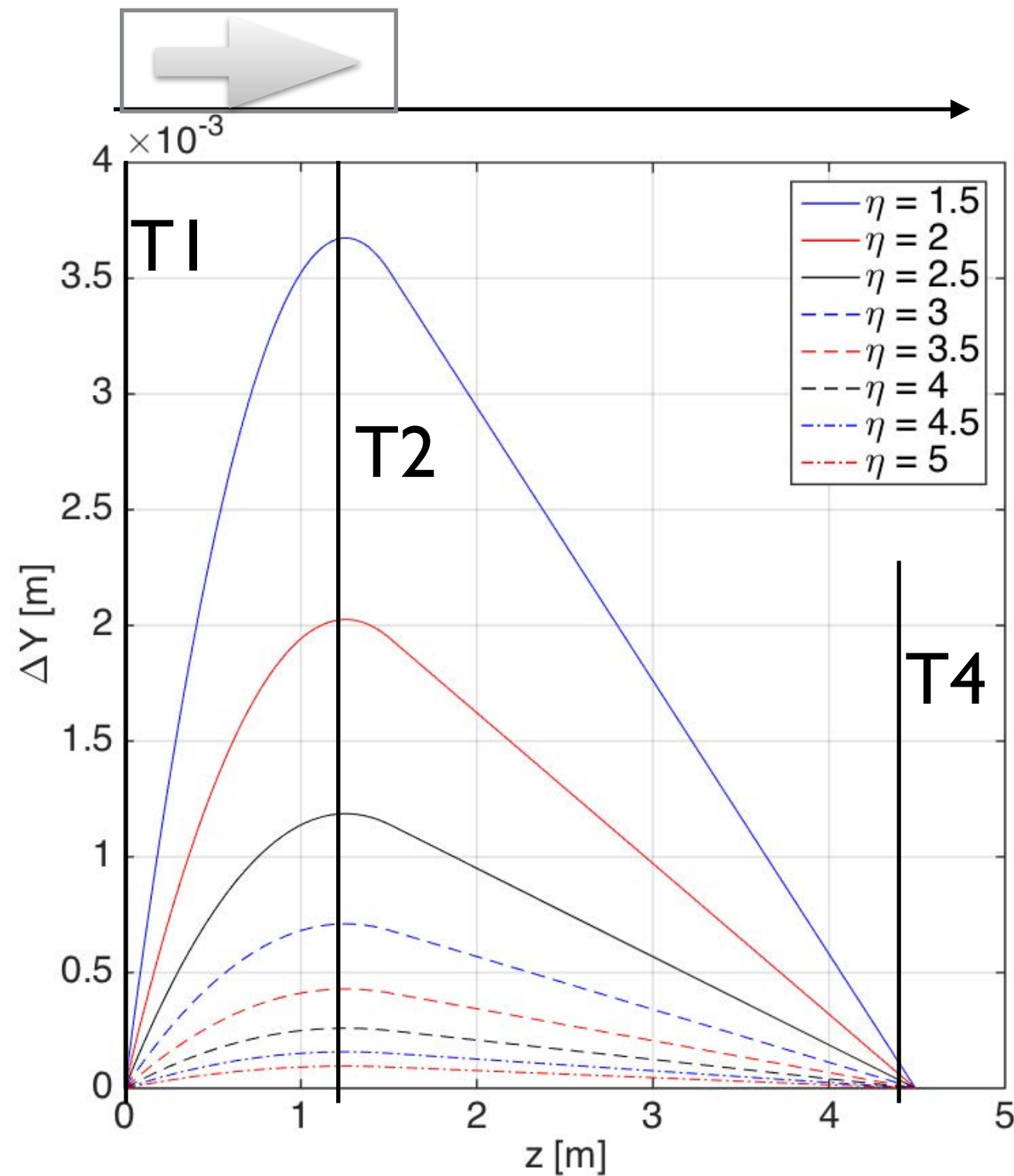


$\eta = 2$

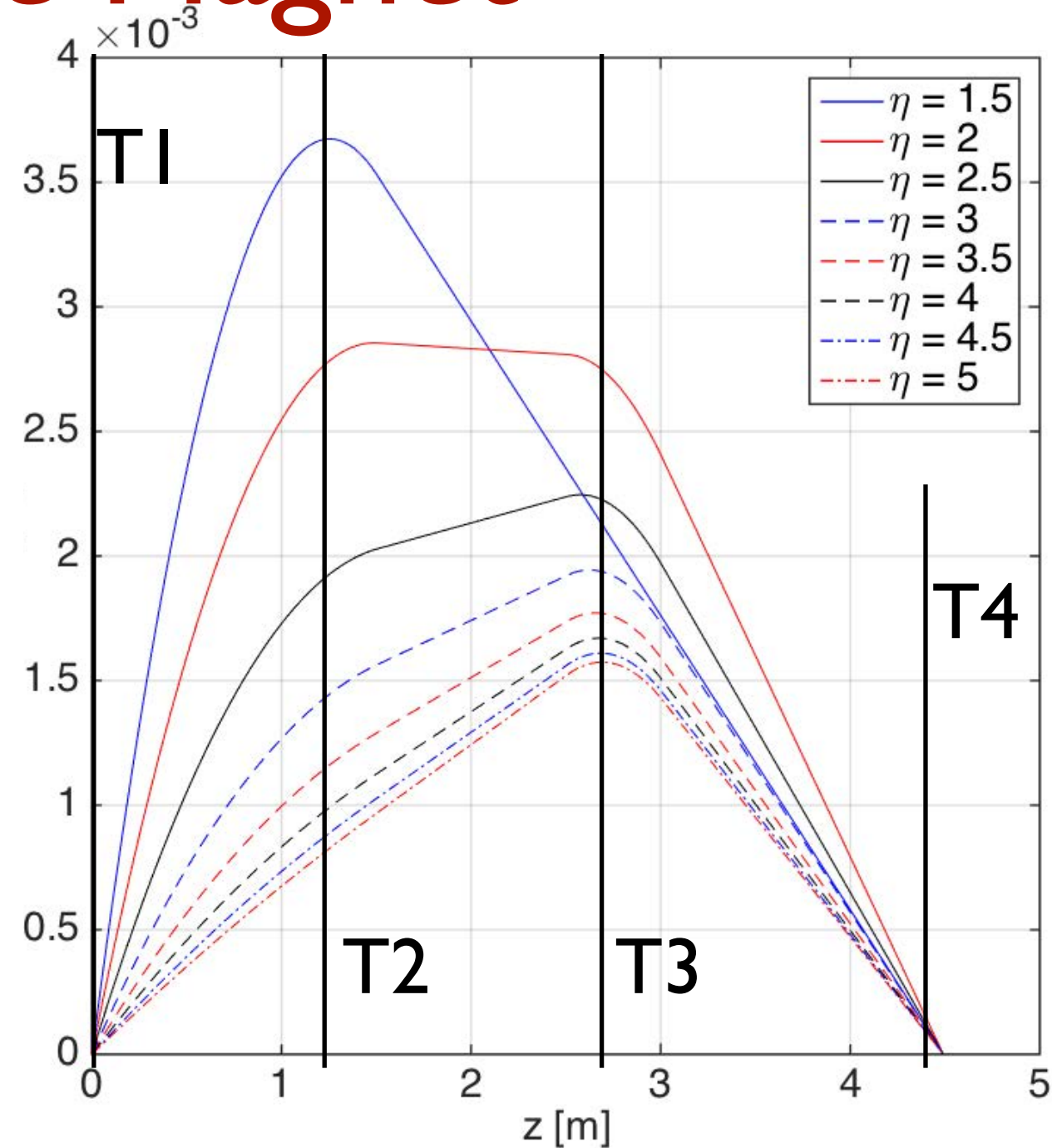
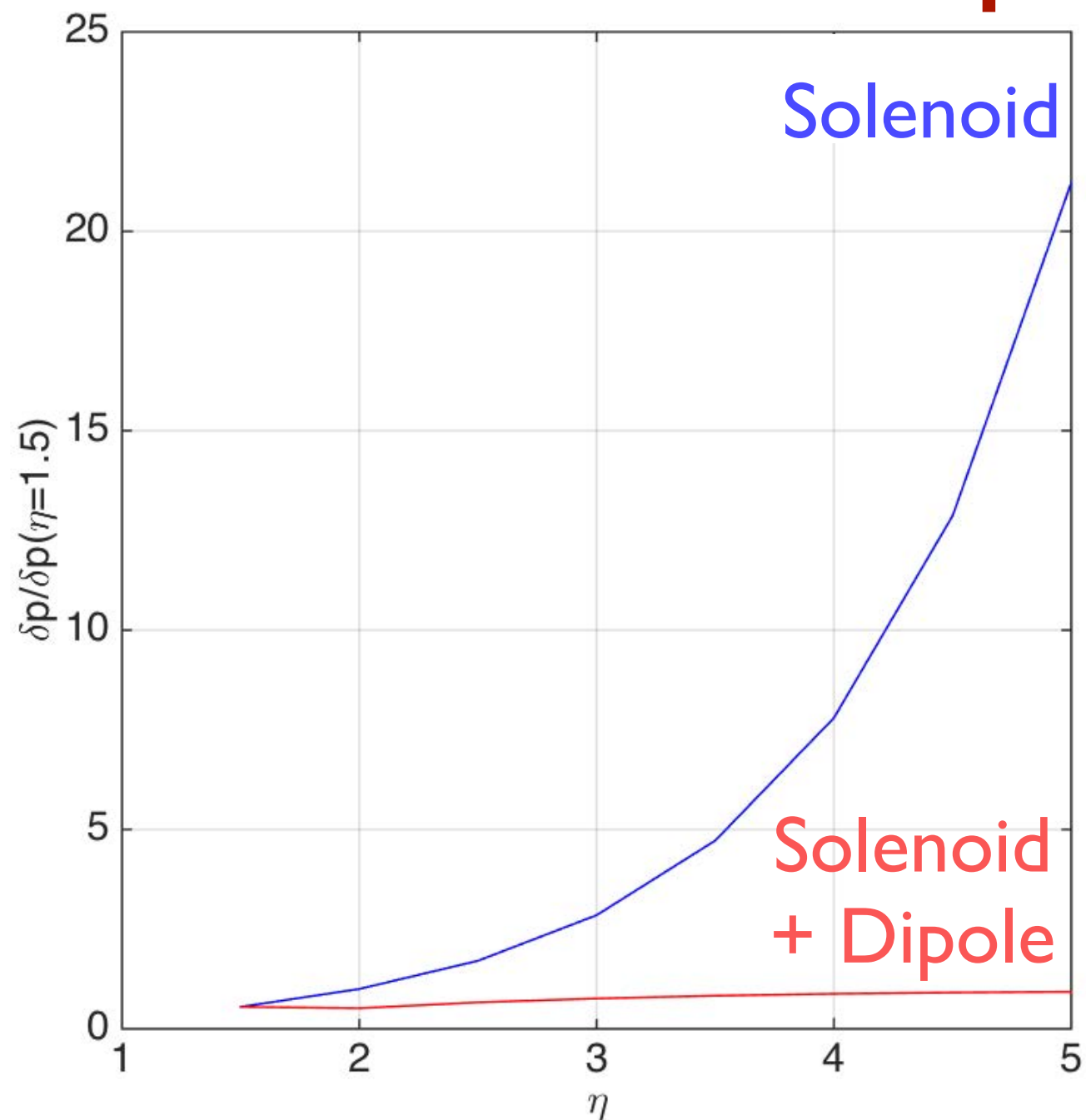


$\eta = 3$

# Track Bending for 50 GeV Particles



# Momentum Resolution Improvement From Dipole Magnet

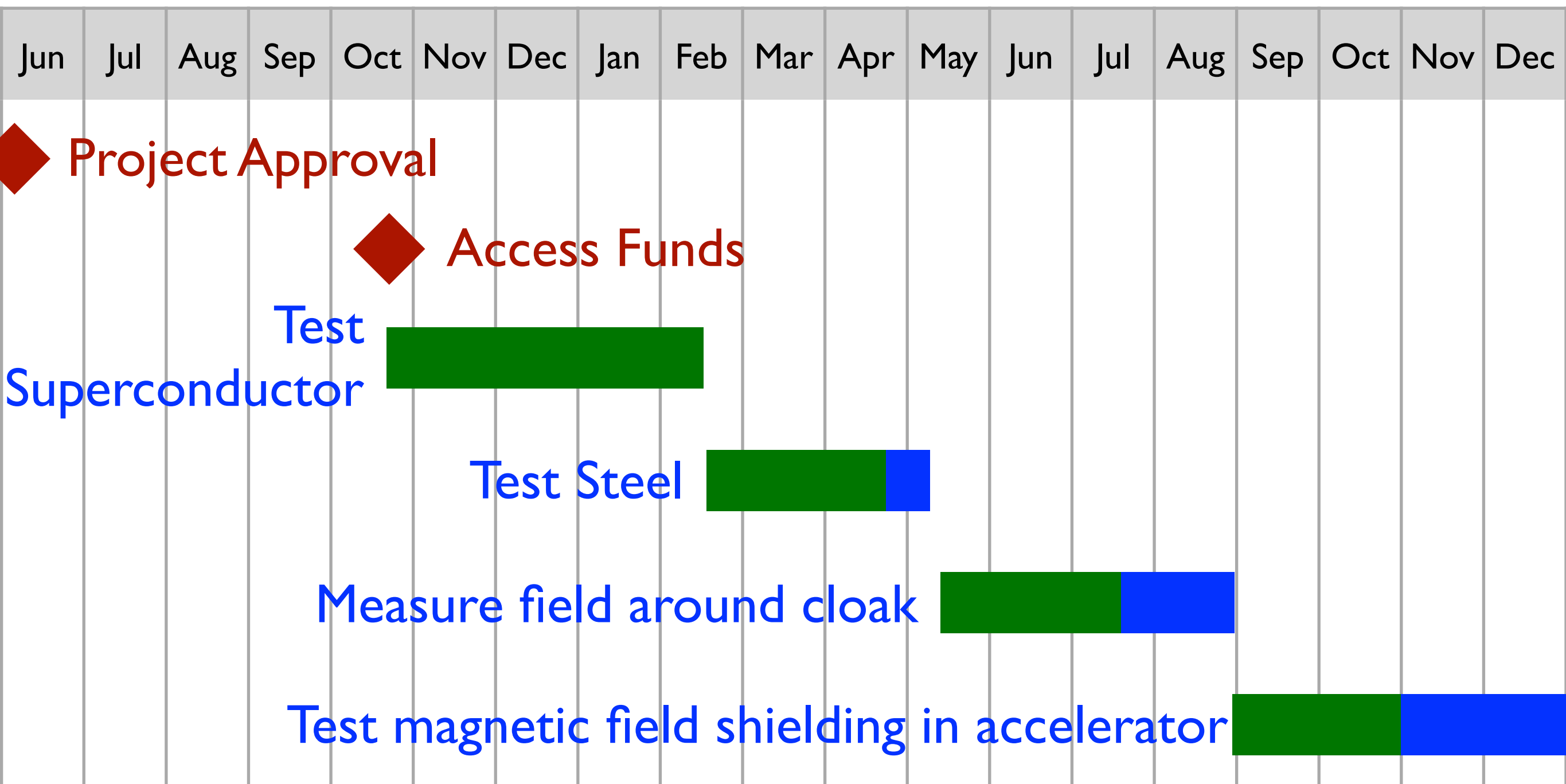




# Project Timeline: Past

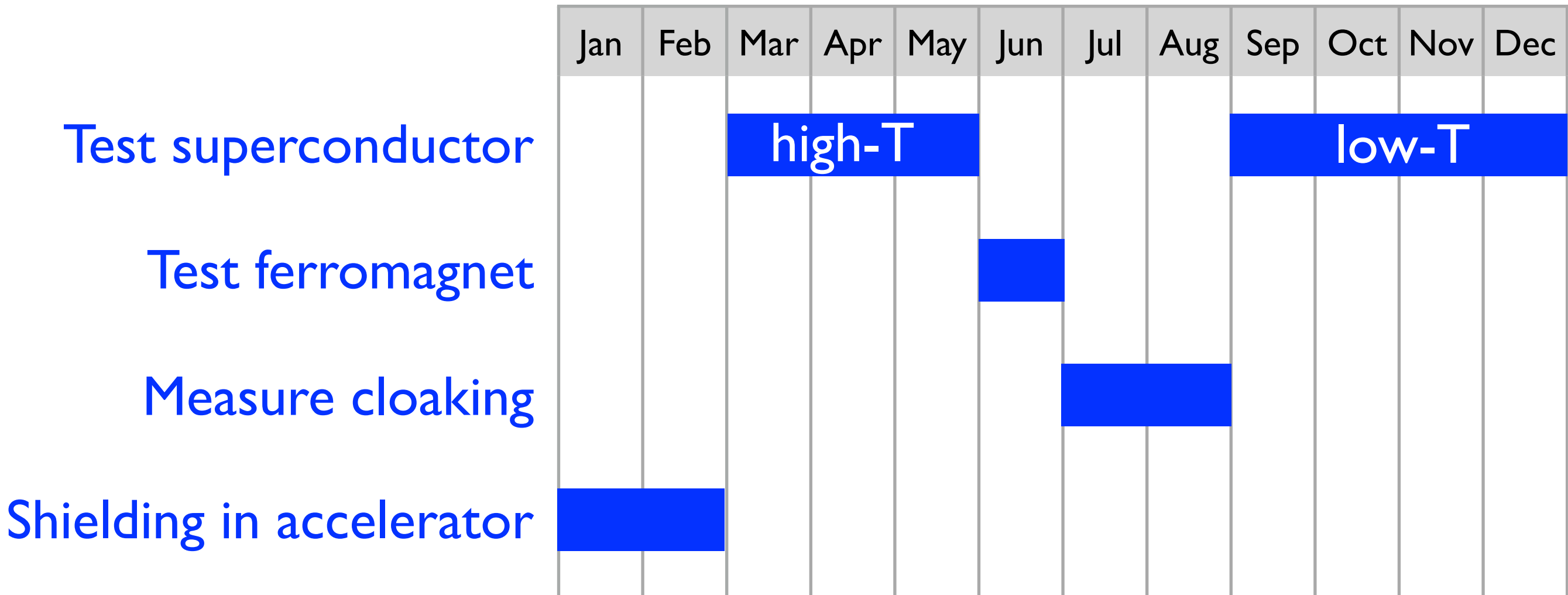
2013

2014



# Project Timeline: Future

2015



# Thanks to all our collaborators!

## *BNL Advisors*

R. Gupta, B. Parker, V. Ptitsyn

## *RIKEN*

Y. Goto, I. Nakagawa

## *RIKEN BNL Research Center*

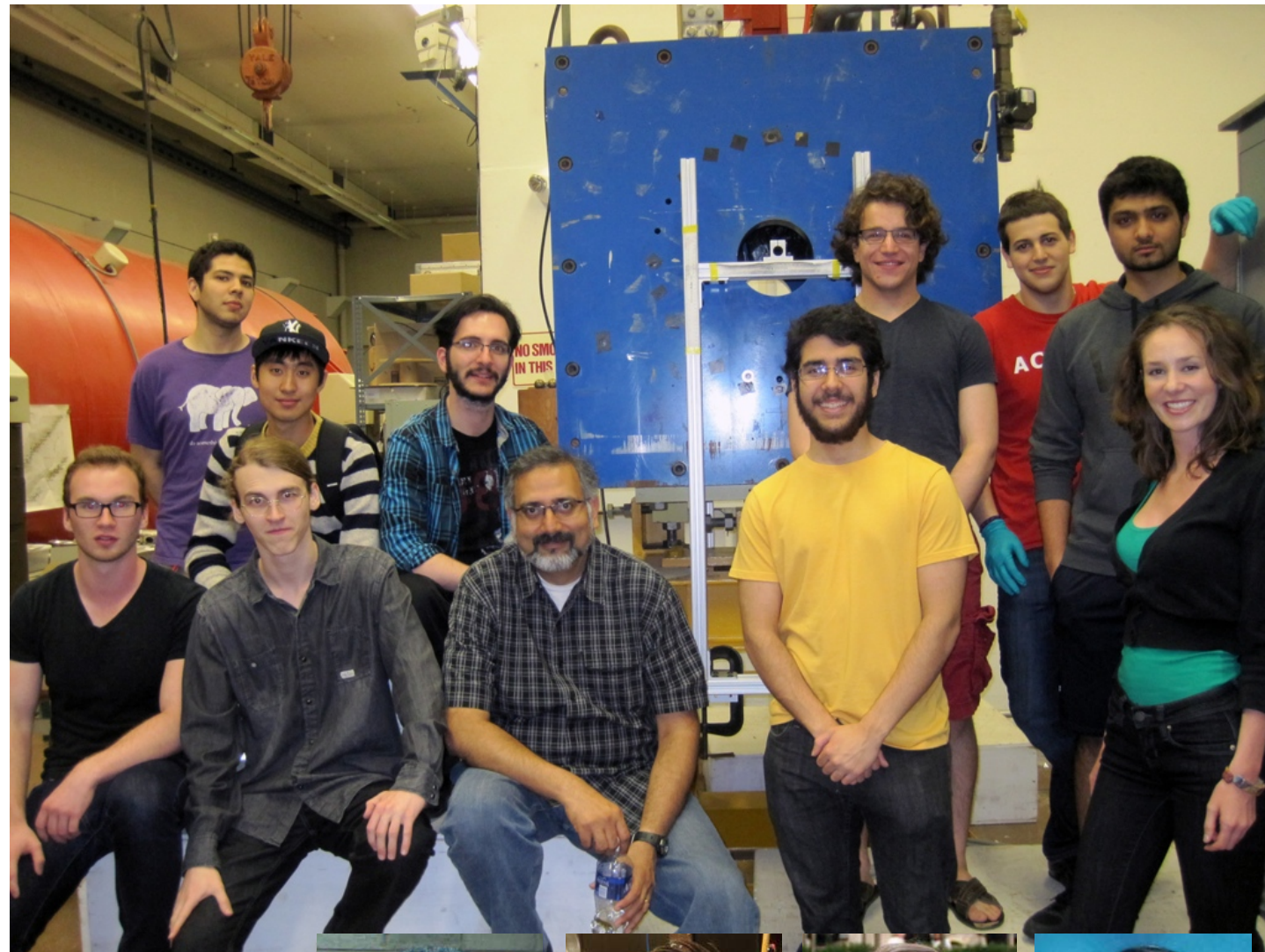
K. Boyle, J. Seele

## *Seoul National University*

I. Yoon

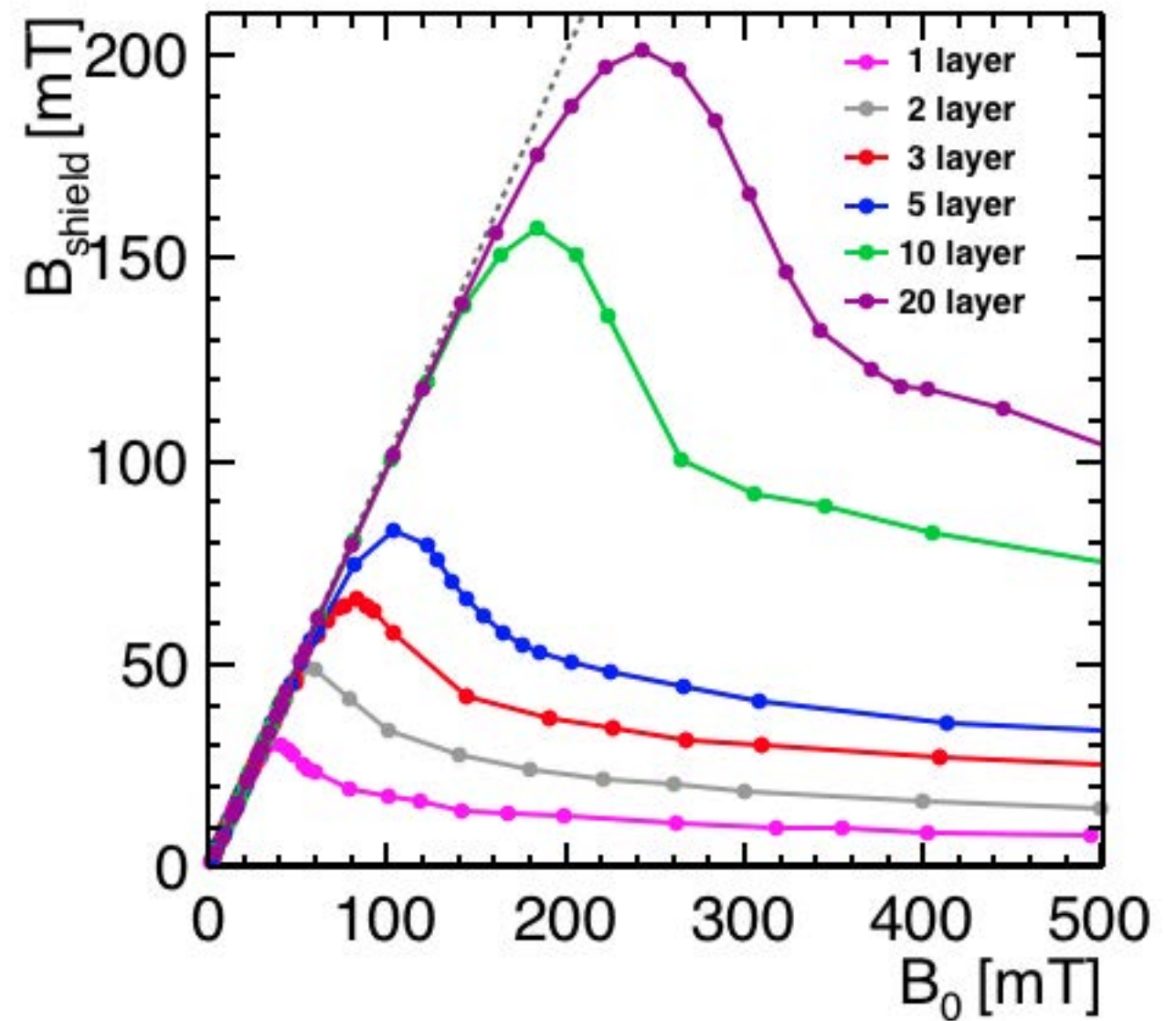
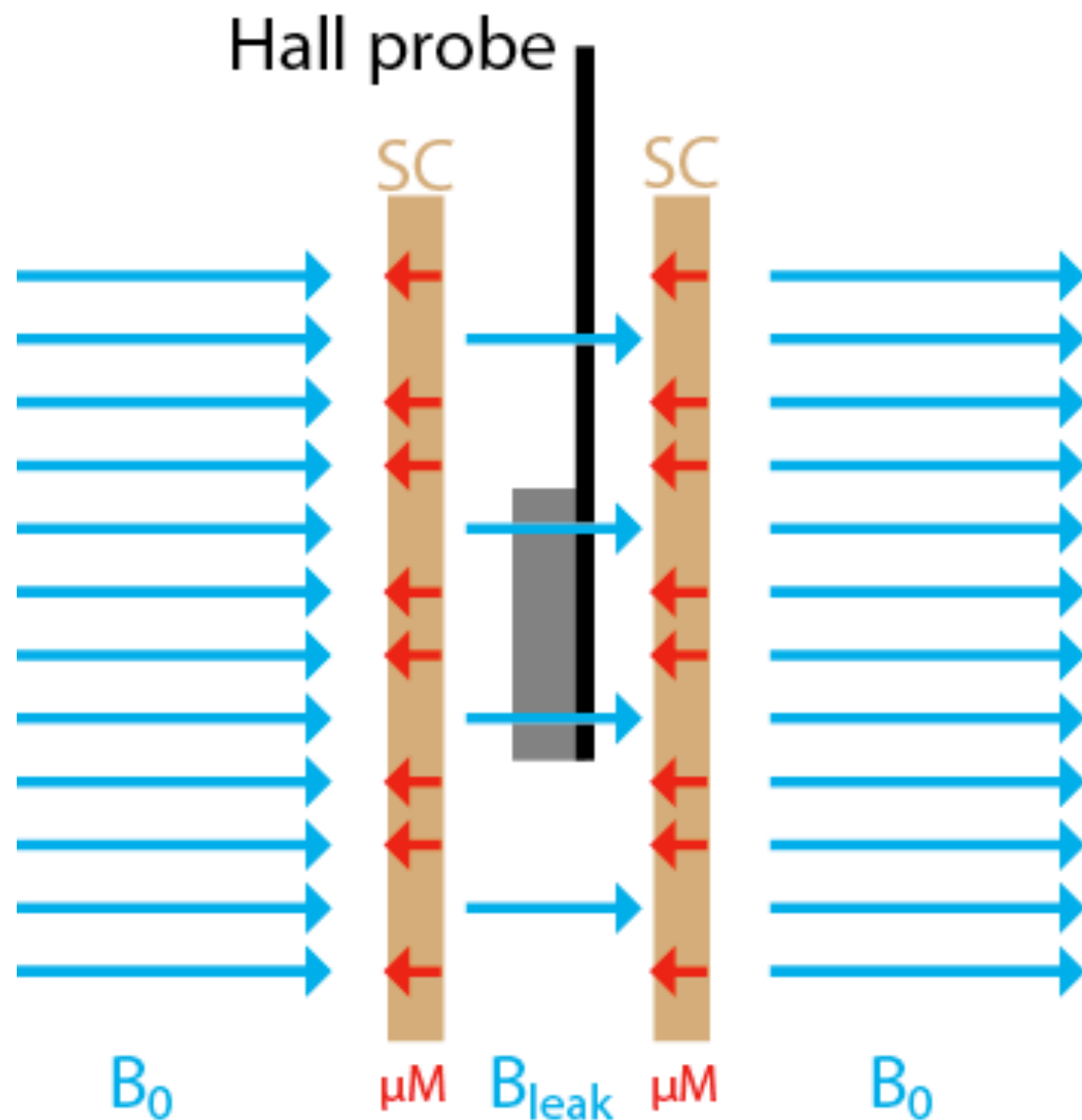
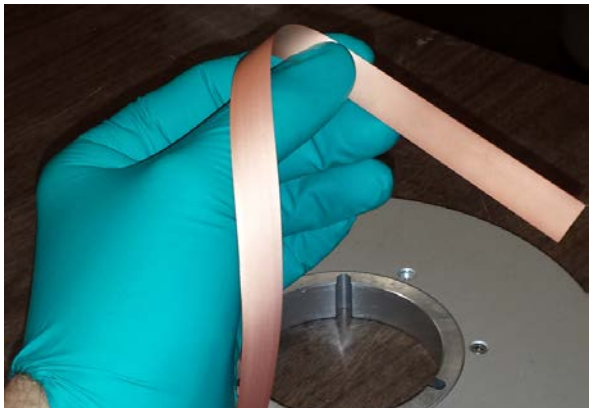
## *Stony Brook University (SUNY)*

K. Capobianco-Hogan, R. Cervantes,  
J. Chang, B. Coe, K. Dehmelt,  
A. Deshpande, N. Feege, T. K. Hemmick,  
P. Karpov, Y. Ko, T. LaByer, R. Lefferts, A. Lipski,  
E. Michael, J. Nam, A. Quadri, K. Sharma

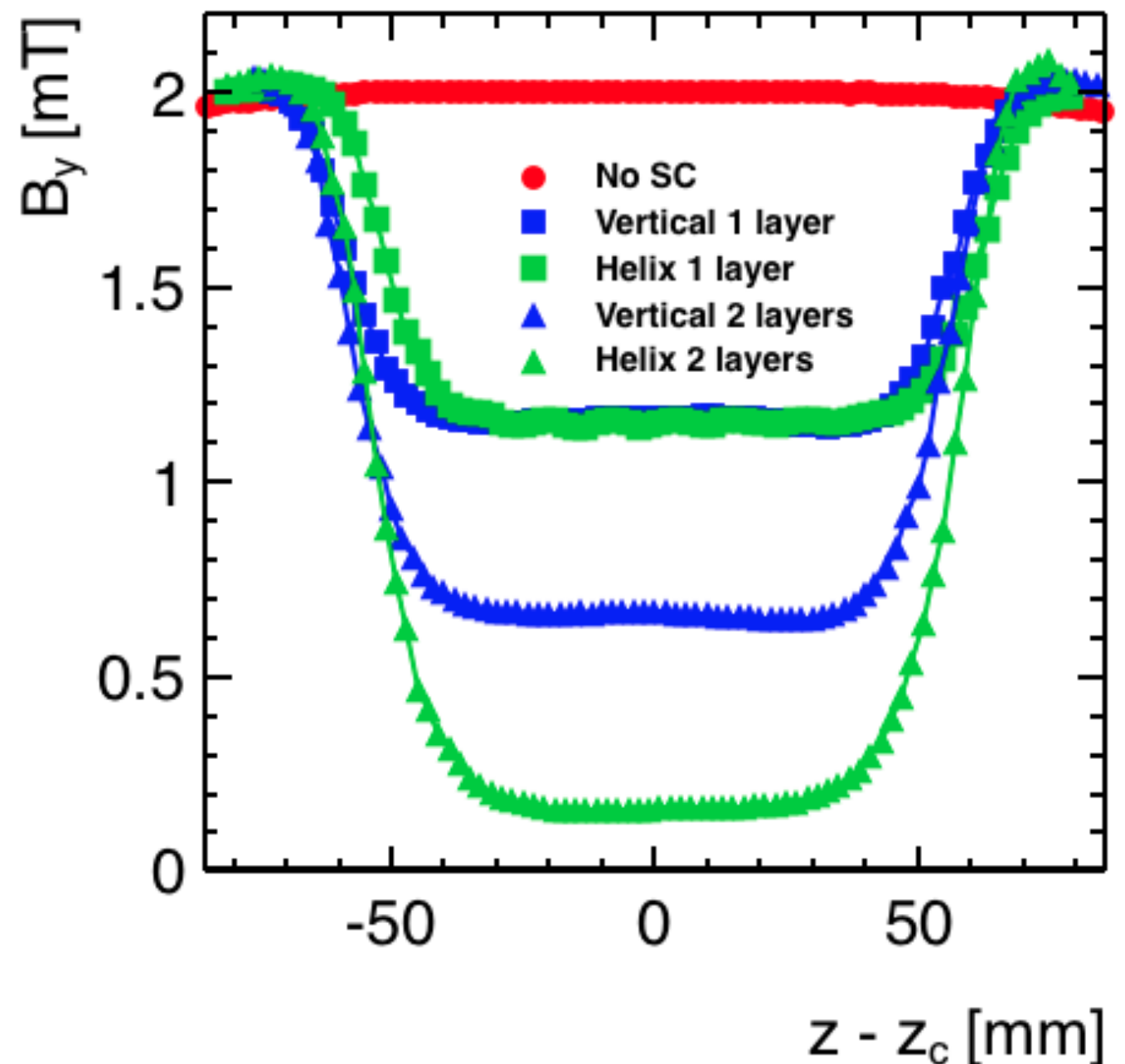
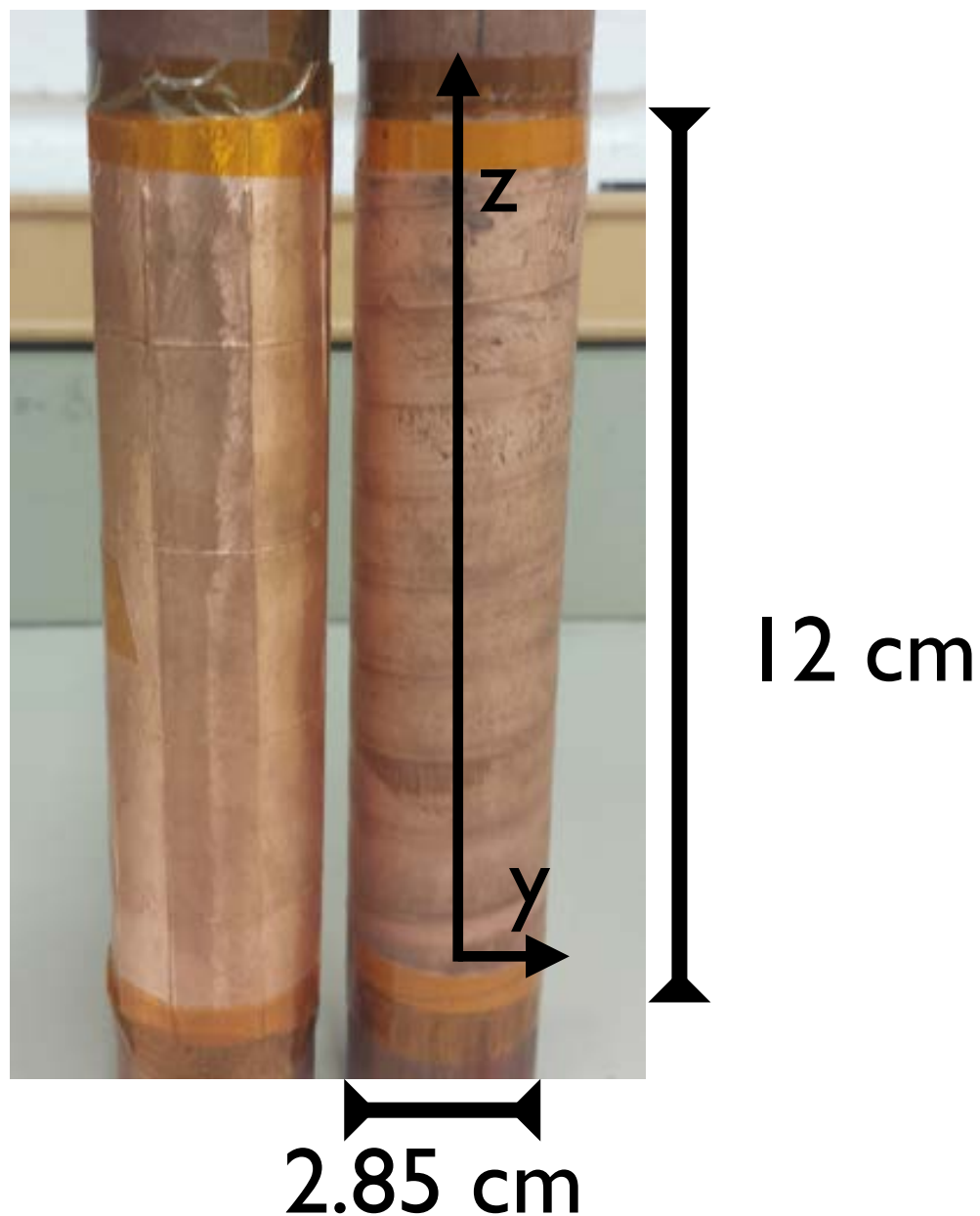




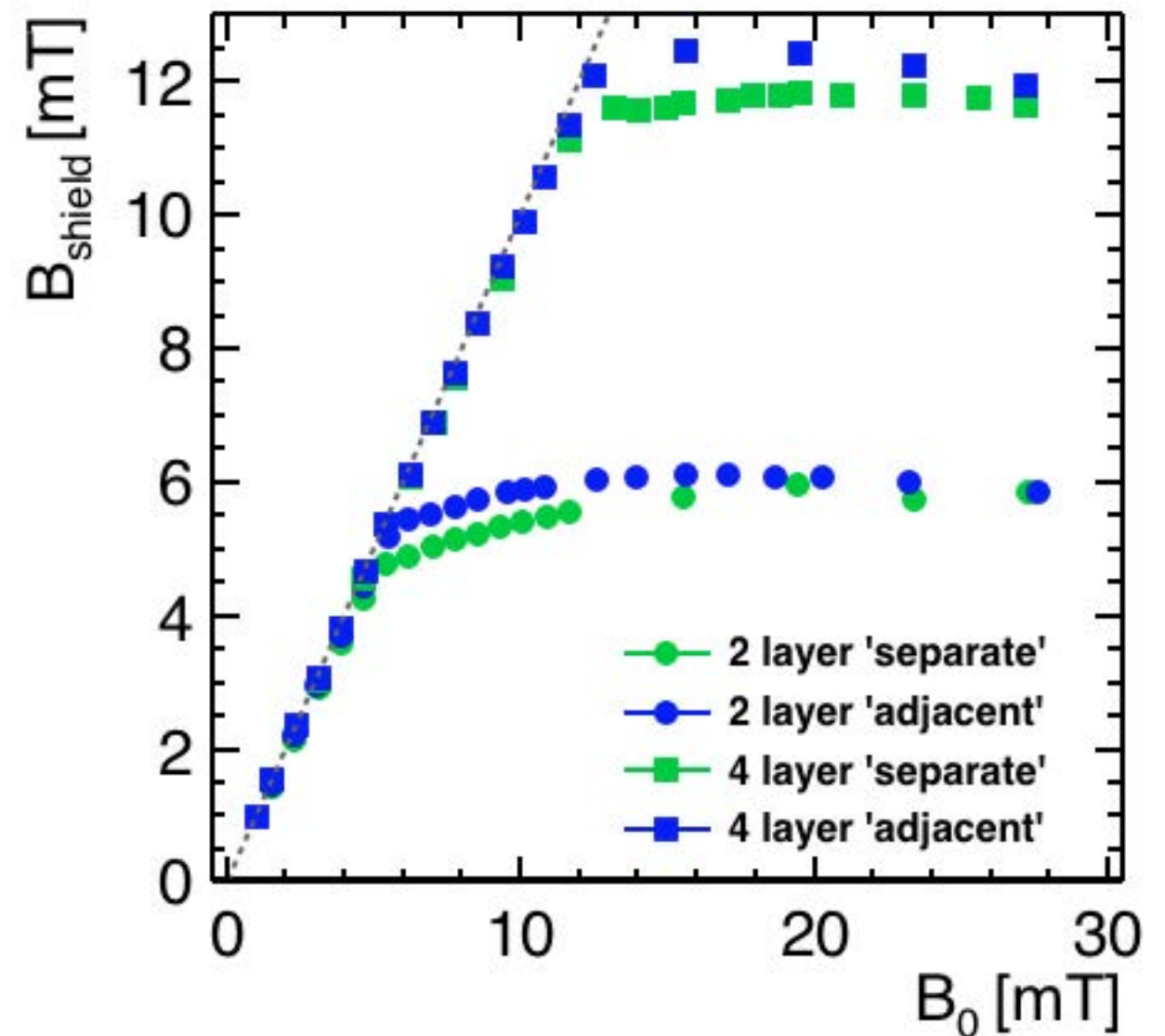
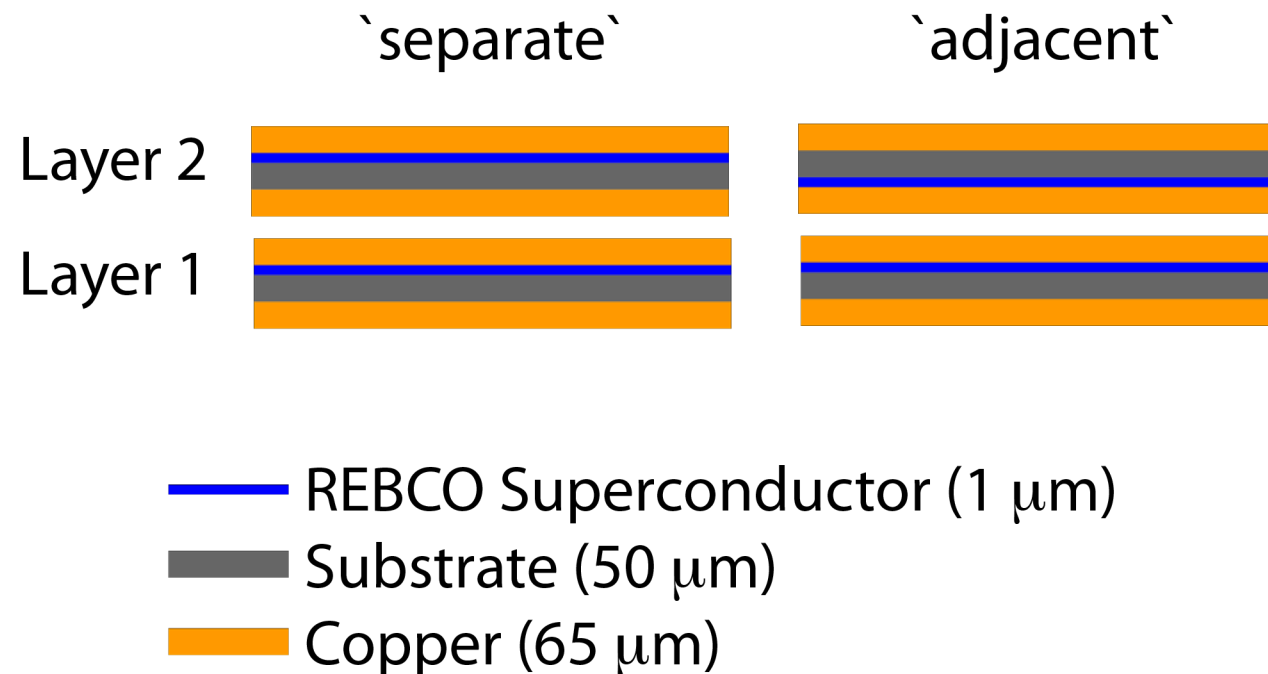
# Multiple Superconductor Layers Improve Shielding



# Comparing SC tape wrapping options: Vertical vs helix



# Varying the distance between subsequent superconductor layers



# Further reducing the gap: SC tape without copper stabilizer



w/o Cu stabilizer

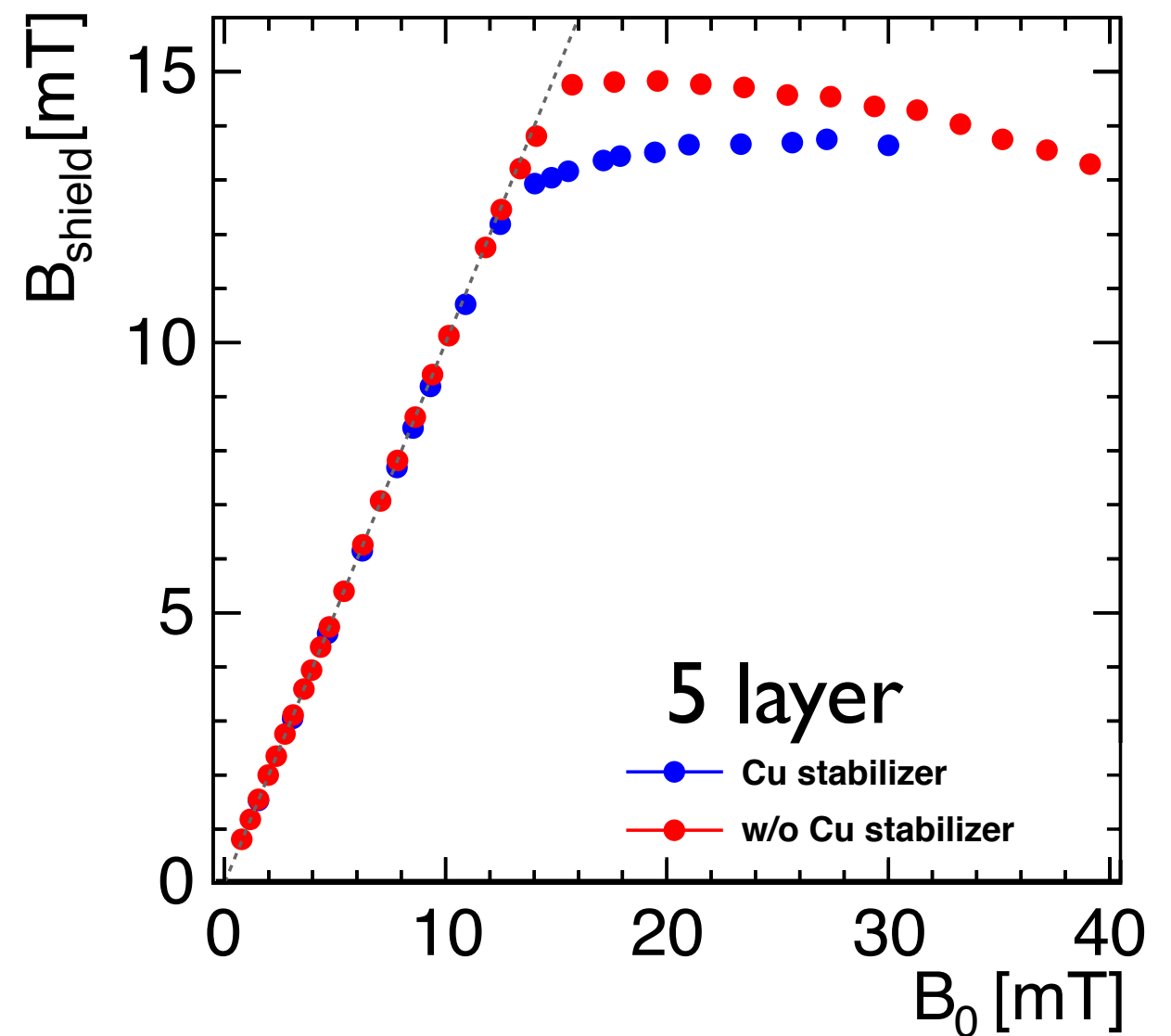
Layer 2



Layer 1

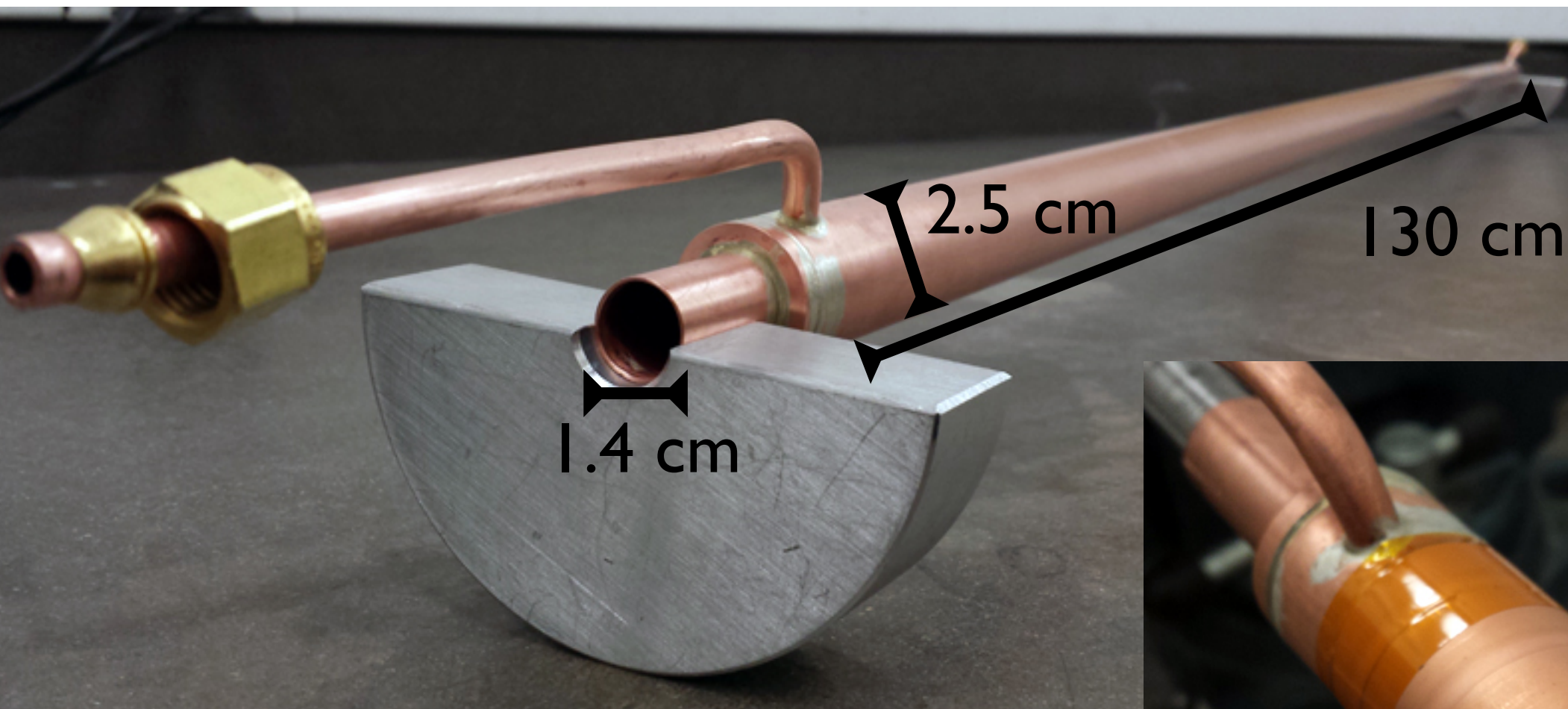


- REBCO Superconductor ( $1\ \mu\text{m}$ )
- Substrate ( $50\ \mu\text{m}$ )
- Copper ( $65\ \mu\text{m}$ )





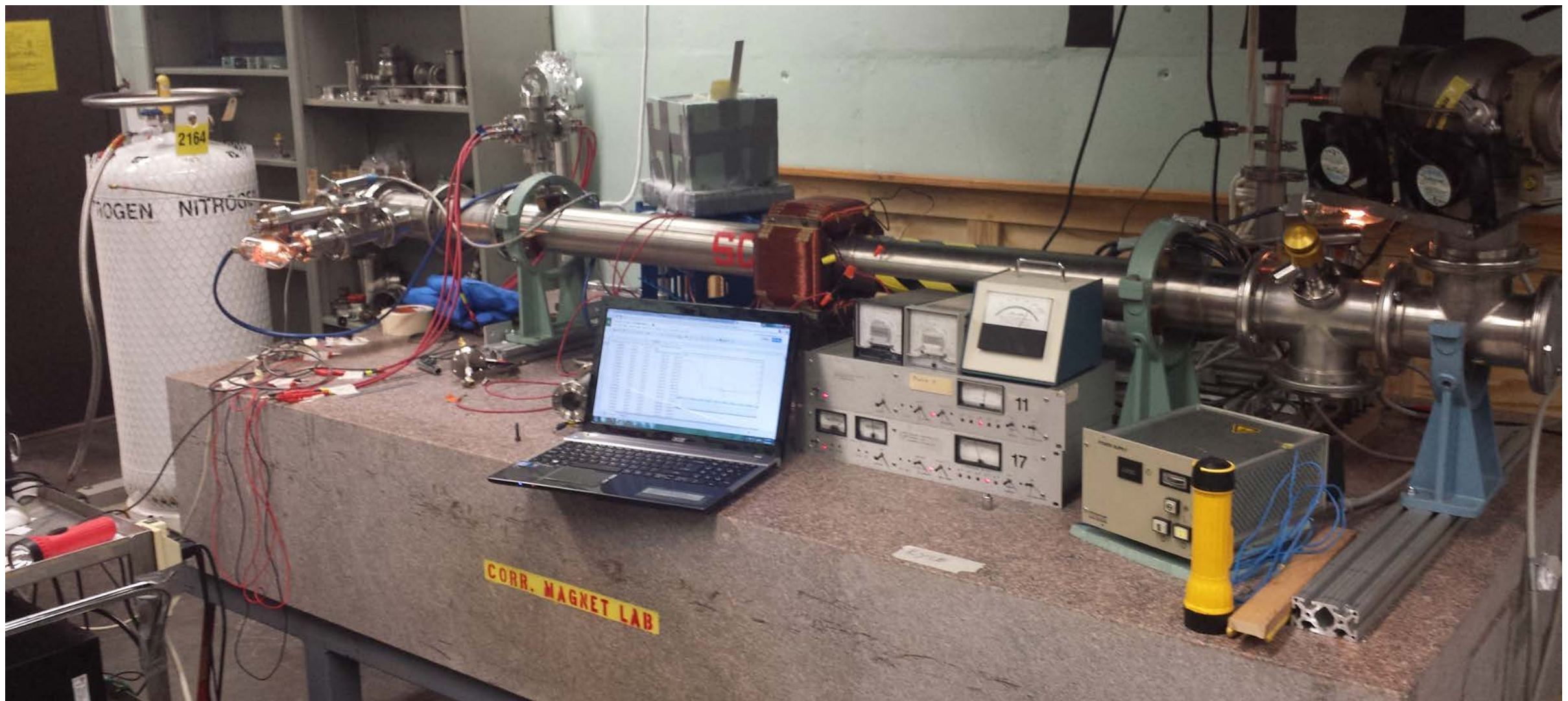
# New cryostat for long magnetic field shield (Van de Graaff test)



5 layers 'helix adjacent' SC tape

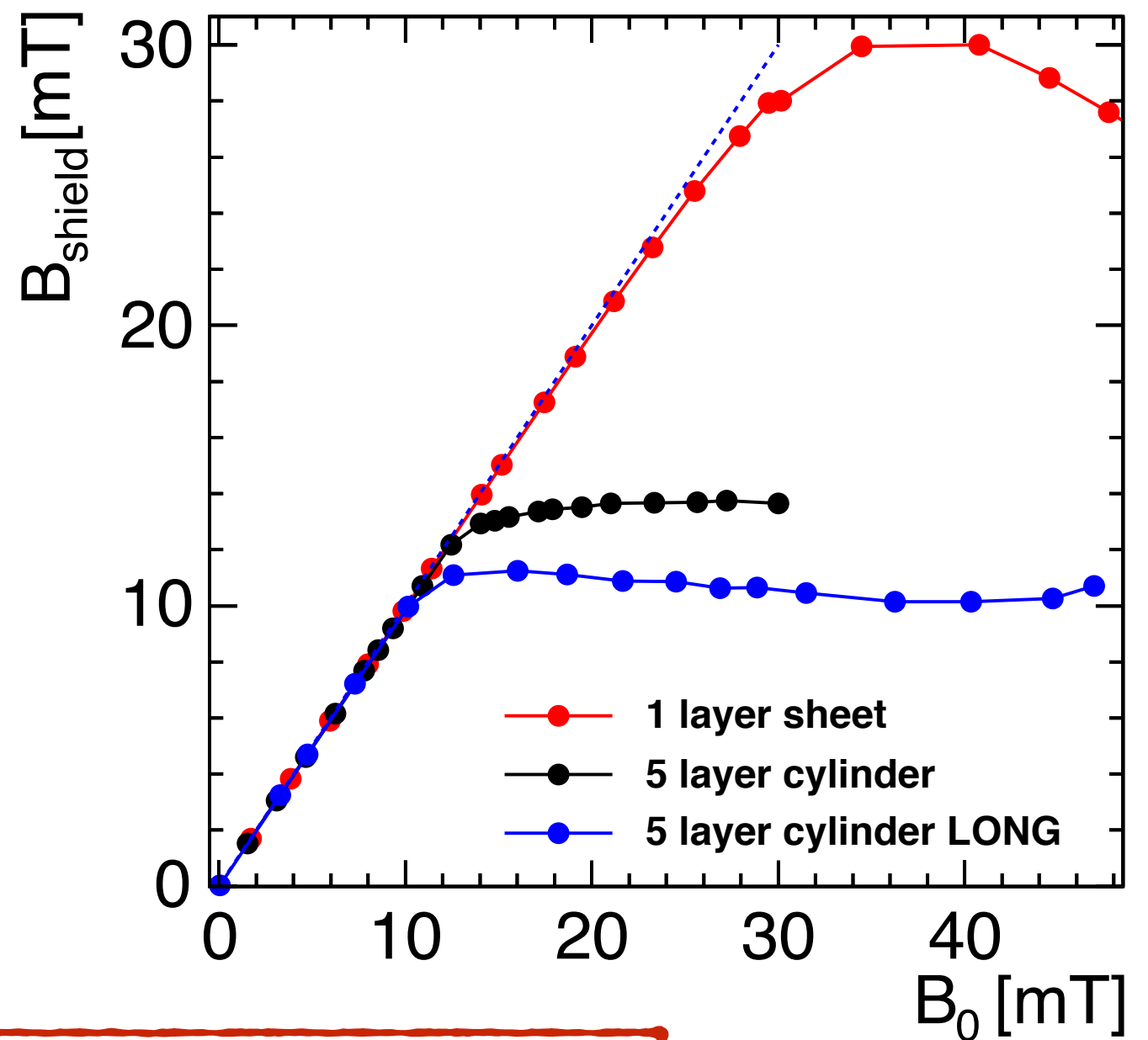
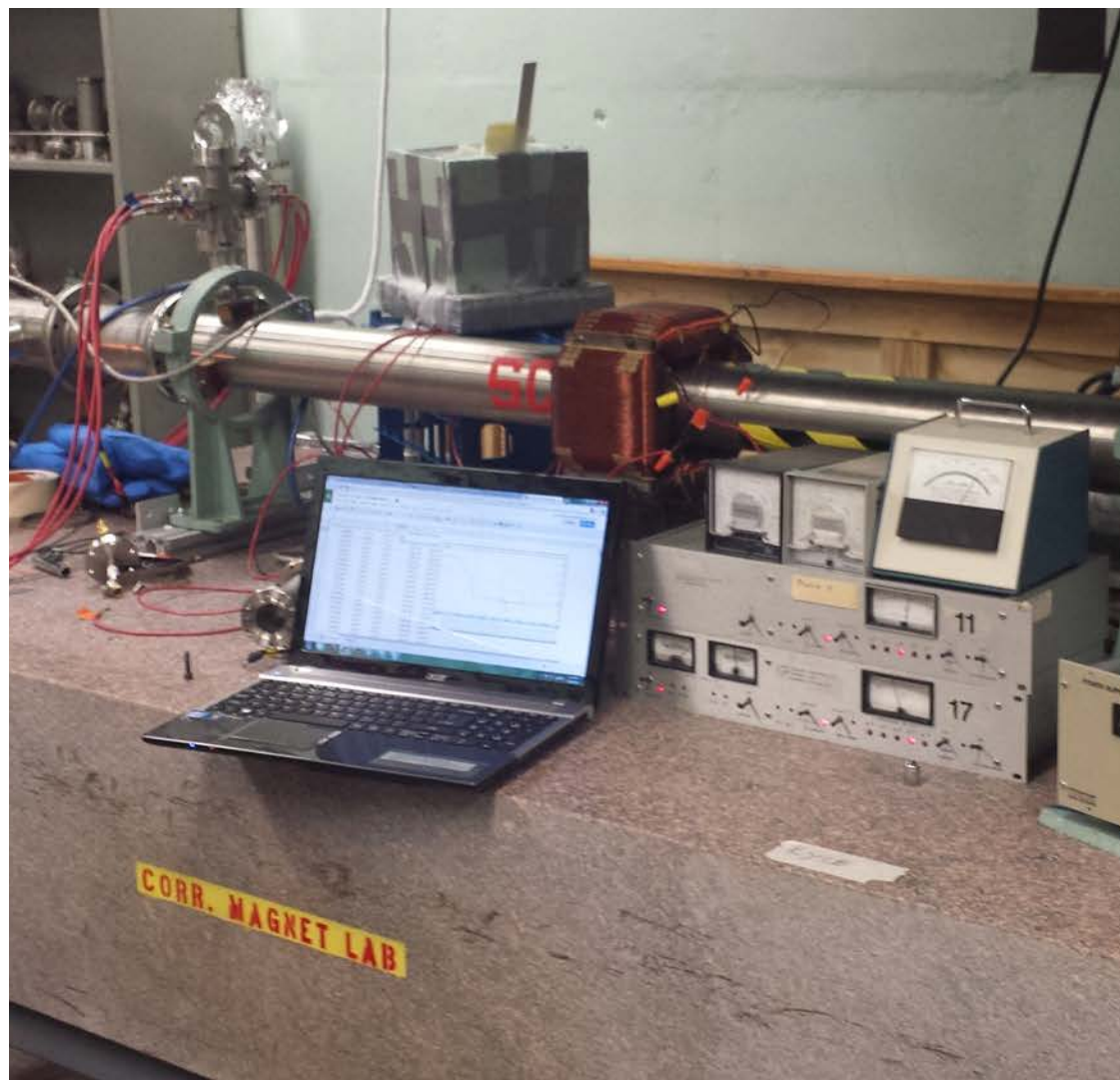


# Long prototype fully commissioned



New Cryostat works: Outer SC layer at 78.5 K

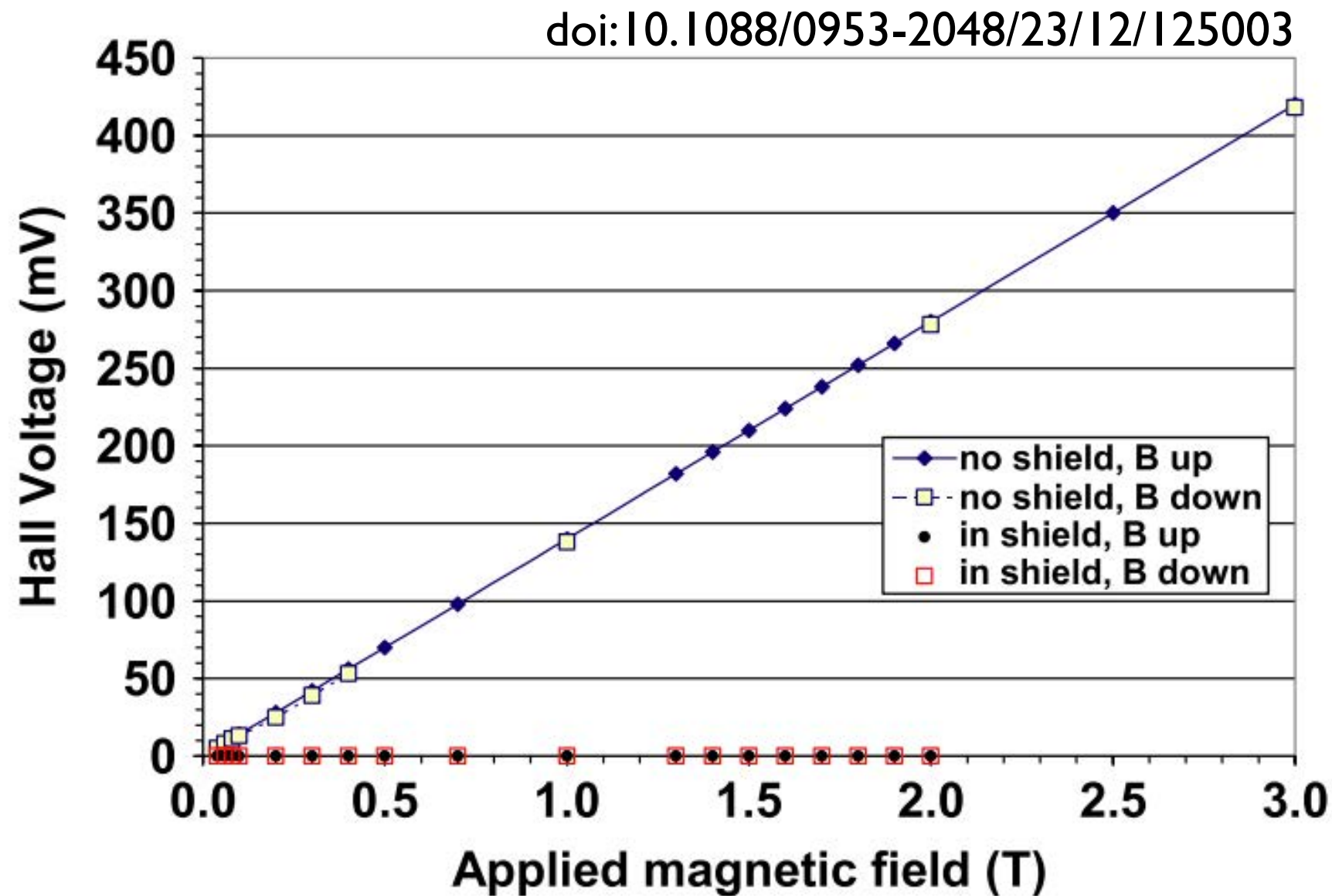
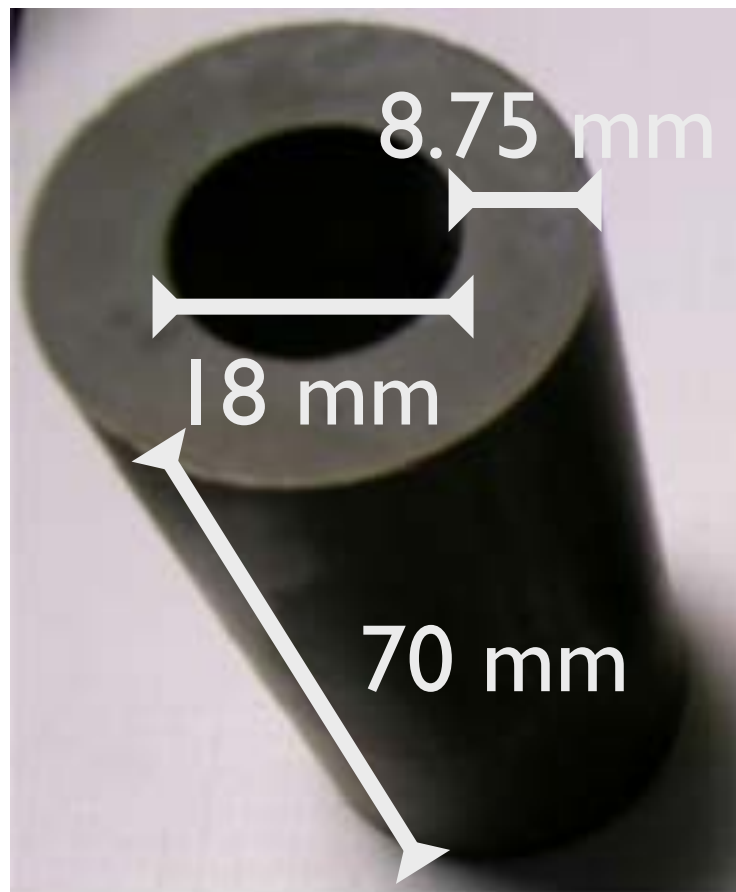
# Long prototype fully commissioned



**We're ready for test with beam!**



# Alternate Superconductor Option: Magnesium boride ( $\text{MgB}_2$ )

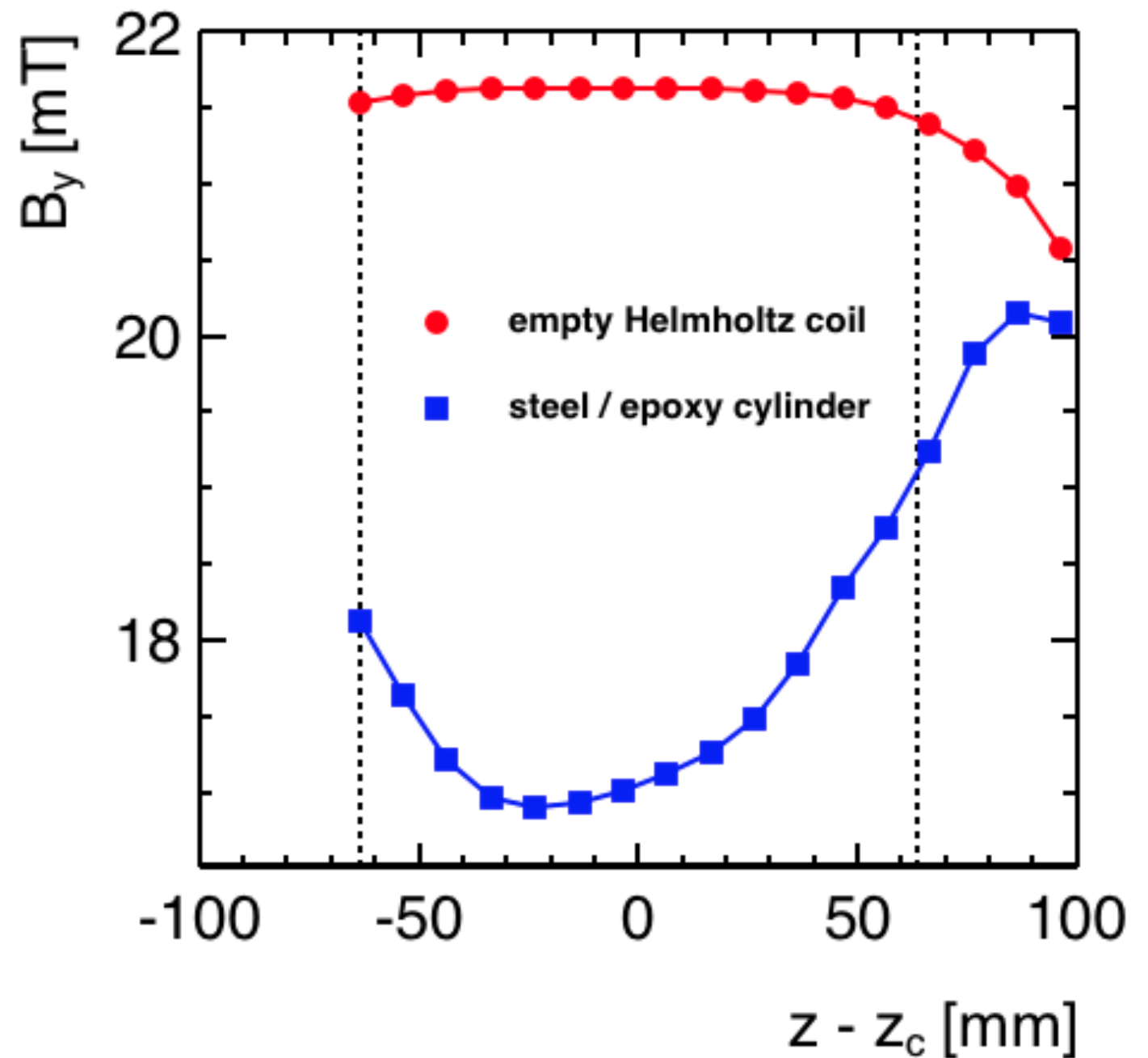




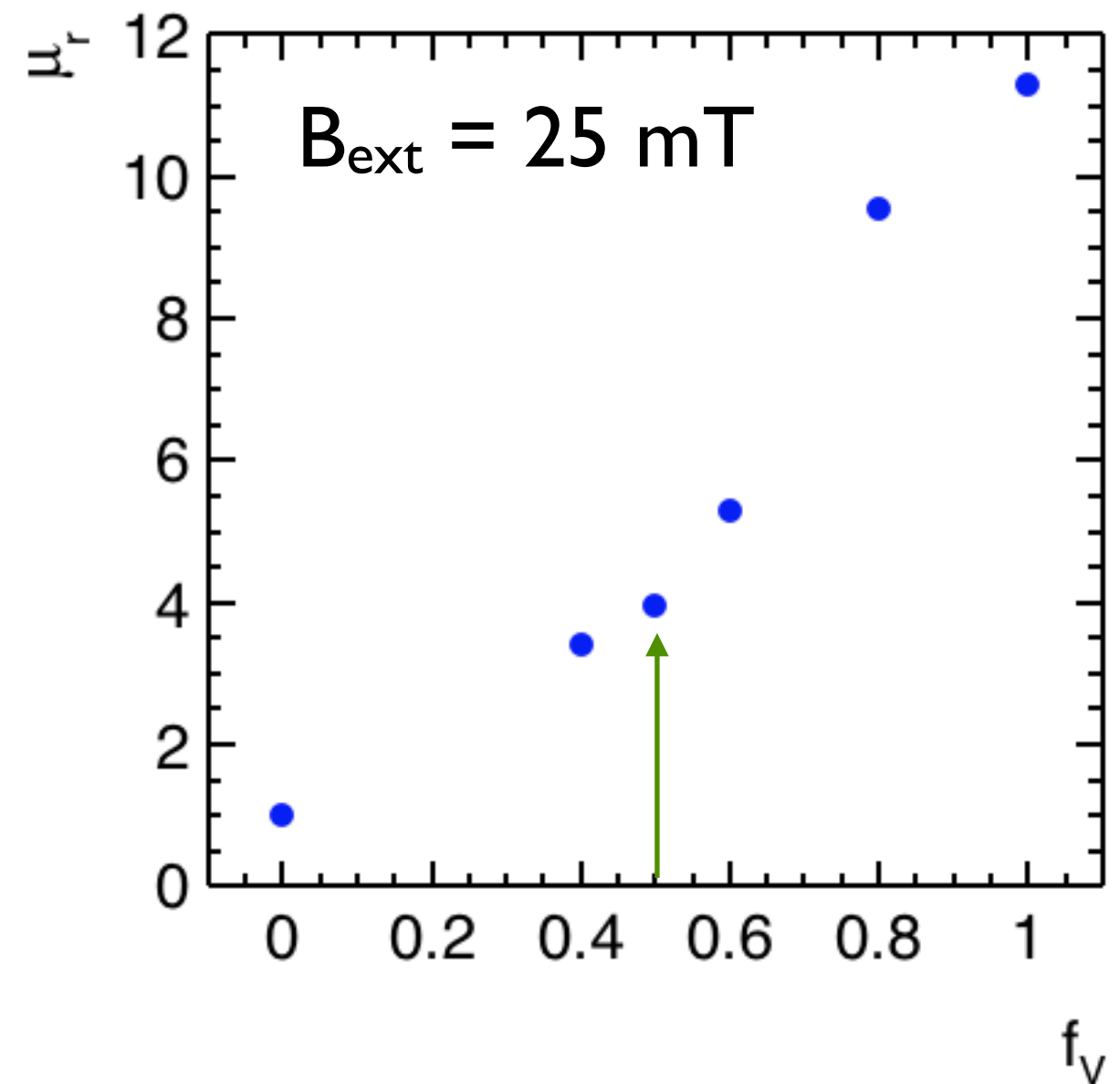
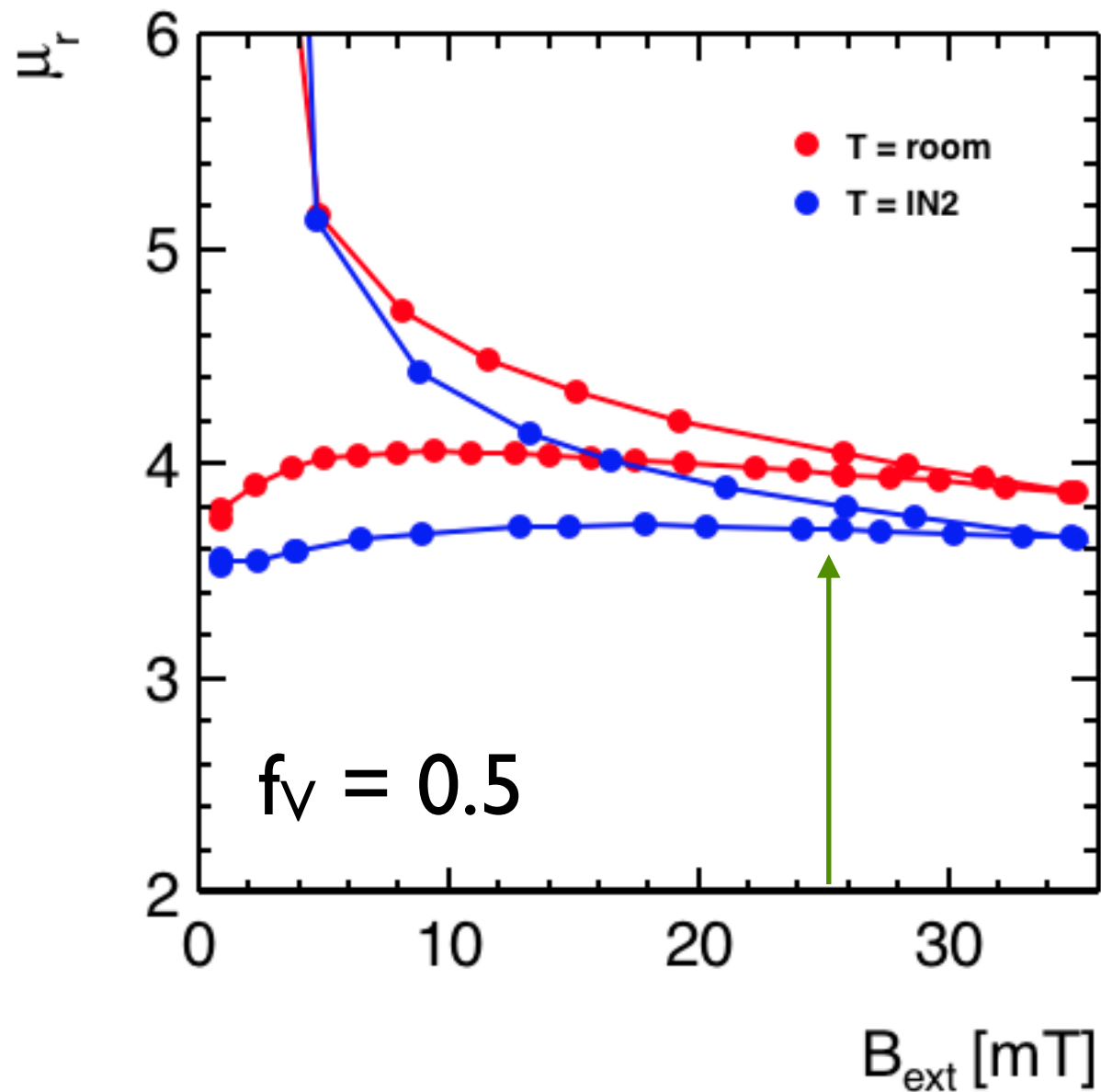
# Ferromagnetic Layer: Epoxy and Stainless Steel Mixture



430 Stainless Steel Powder



# Ferromagnetic Layer: Epoxy and Stainless Steel Mixture

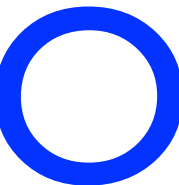


# Open Questions

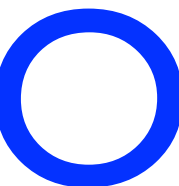
*What is the physics benefit (quantitative) for a conceptual forward dipole spectrometer?*



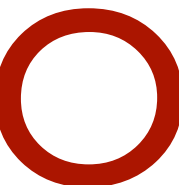
*What is the effect of the end-field on the accelerator performance?*



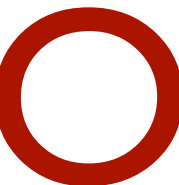
*What is the radiation hardness of the ferromagnetic and superconducting material?*



*What is the effect of a possible cryostat and its flanges on the detector acceptance and performance at small angles?*



*Could thermal effects due to accidental beam dumps damage the structure?*



# Preliminary Budget Estimate FY16

Item	Cost Estimate [\$]
Post-doc salary (3 months) + fringe benefits	12,500 + 5,500
Graduate student salary (1 year) + fringe benefits	25,000 + 8,000
Travel expenses	2,500
Superconductor (NbTi/Nb/Cu, 2 sheets)	10,000
Superconductor (MgB <sub>2</sub> , powder, processing)	(soon)
Liquid Helium supplies	5,000
BNL Superconducting Magnet Division Services	(next week)
Total	68,500
Overhead (indirect)	34,000
Preliminary Estimate FY16	\$102,500 + X



# Summary

Continuous progress in quantifying SC tape properties and features of cylinders made from it.

1.3 m long magnetic field shield commissioned and ready for tests in Van de Graaff accelerator.

Epoxy-steel mixture is a viable option for our ferromagnetic material.

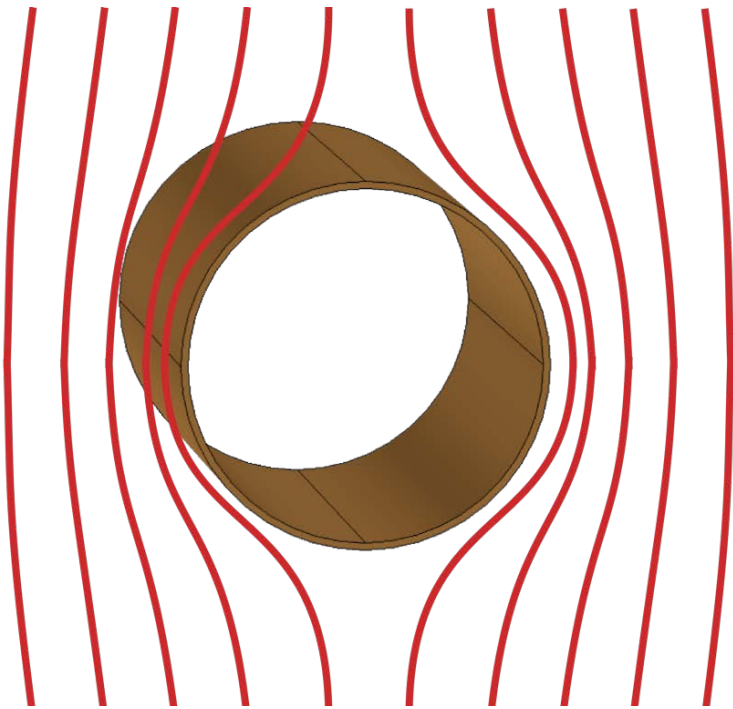
Excellent opportunity for students to collect laboratory experience.

**To be continued...**

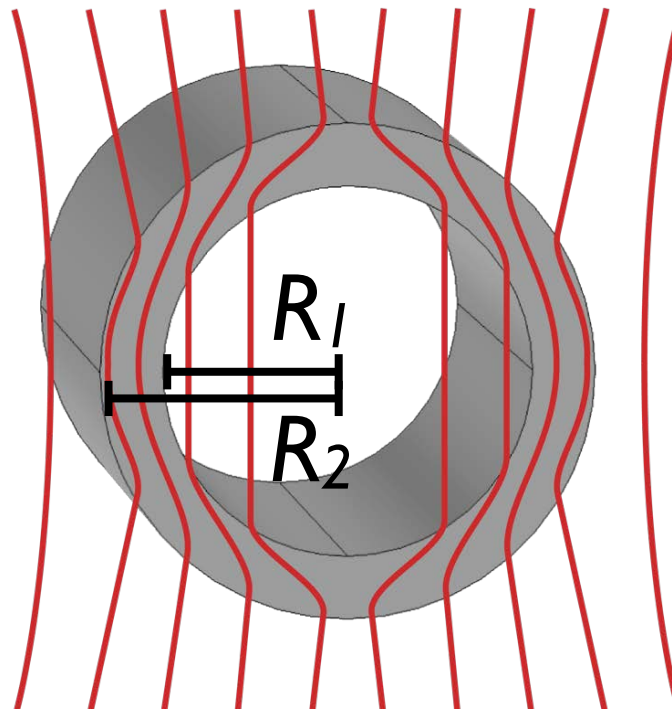
# ***ADDITIONAL SLIDES***

# A simple cylindrical magnetic cloak

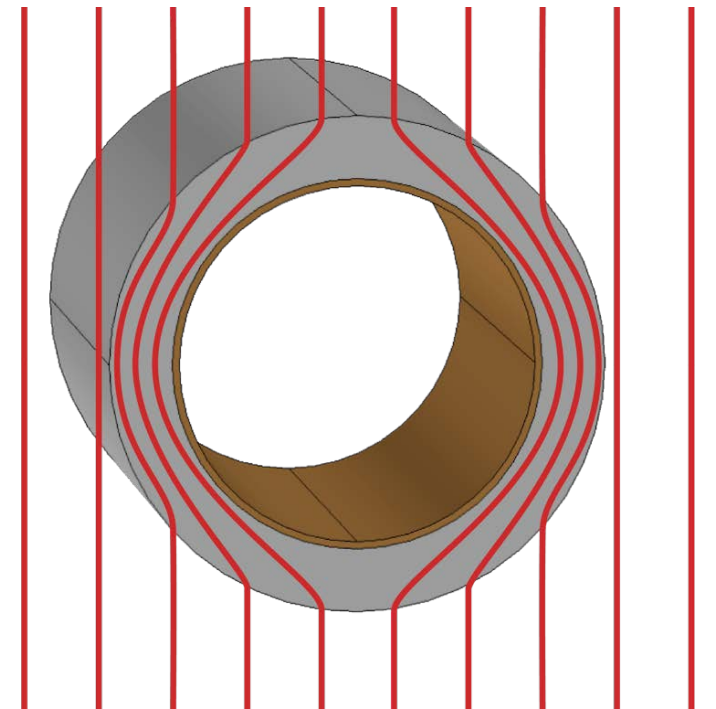
superconducting



ferromagnetic



combined

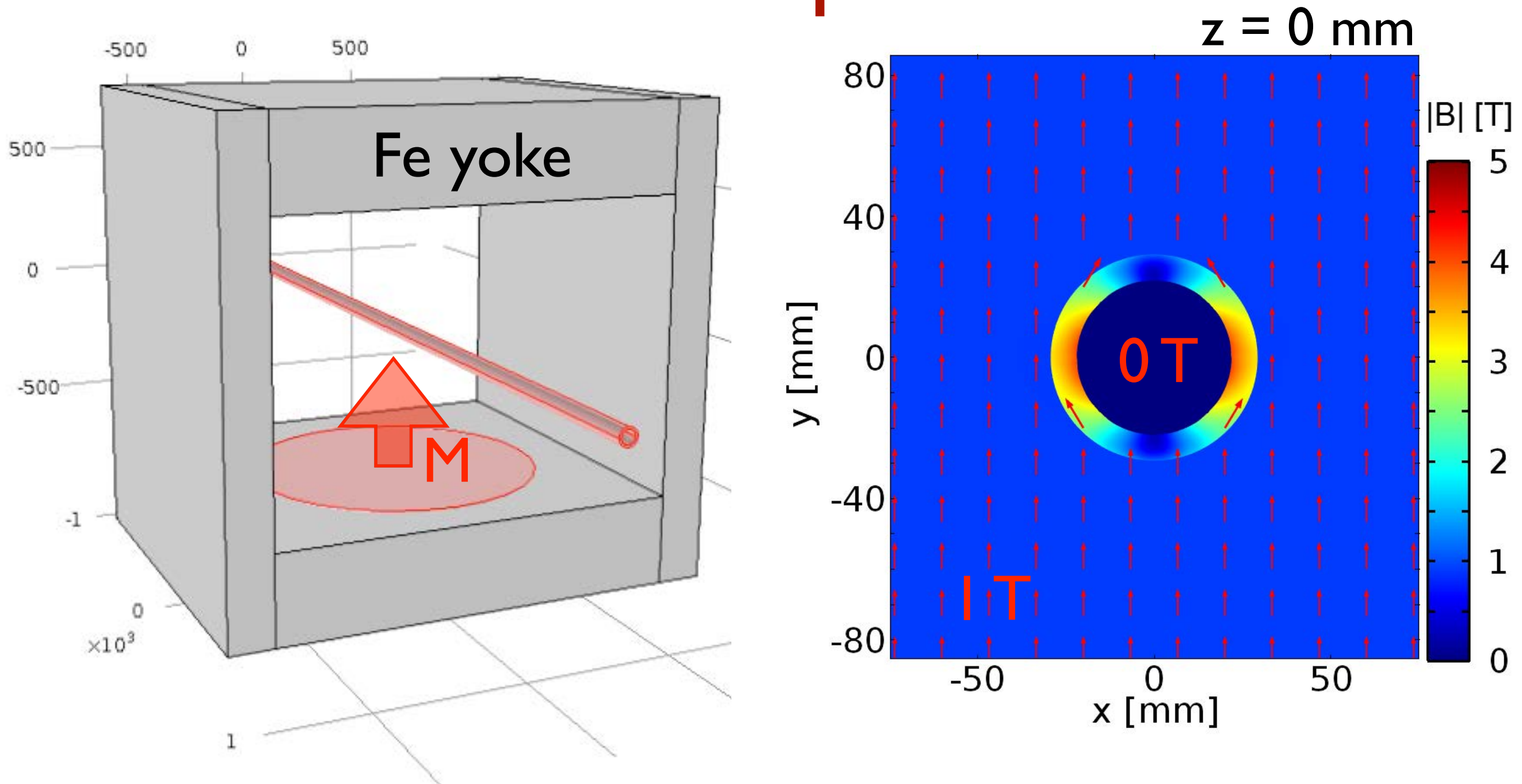


**Perfect cloak:** magnetic permeability (ferromagnetic)  $\mu_2 = \frac{R_2^2 + R_1^2}{R_2^2 - R_1^2}$

Fedor Gömöry et al.

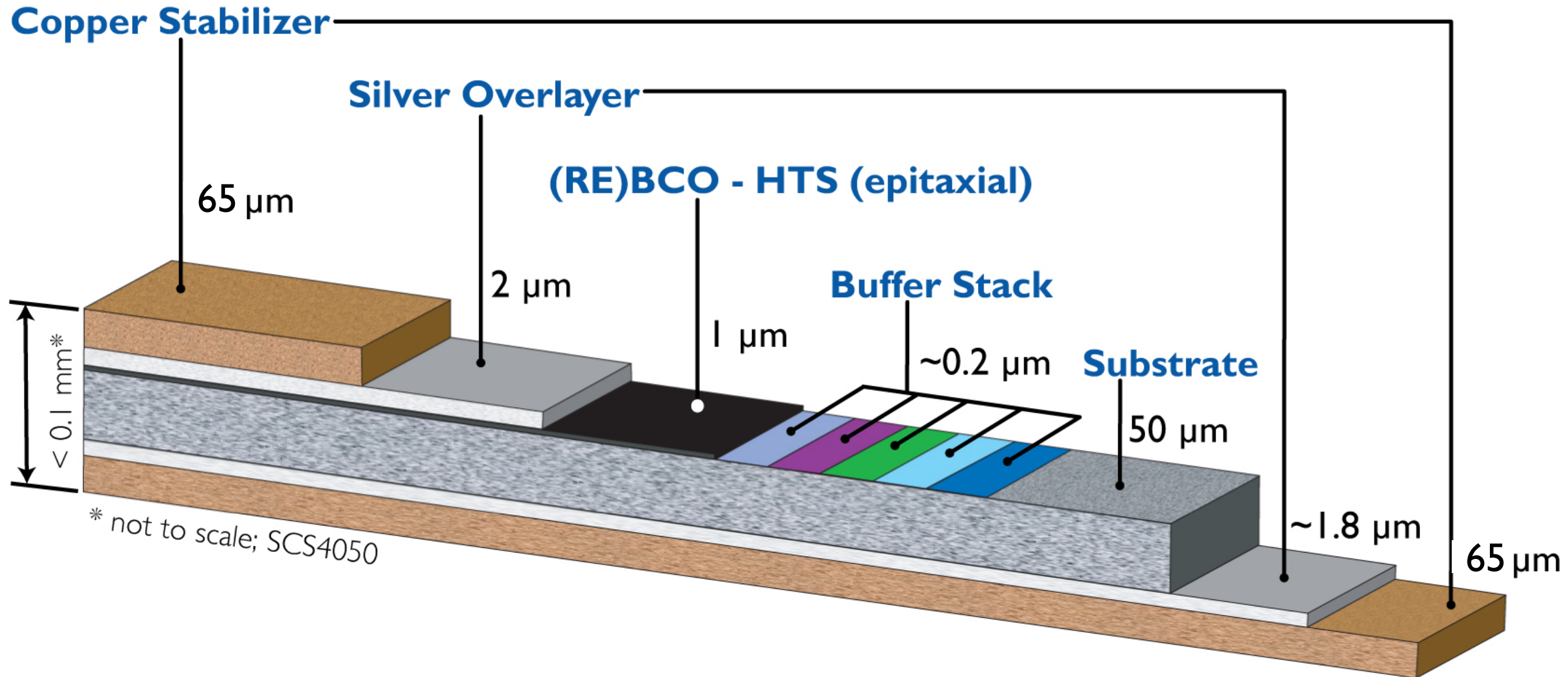
DOI: 10.1126/science.1218316

# COMSOL model of the magnetic cloak in a dipole field

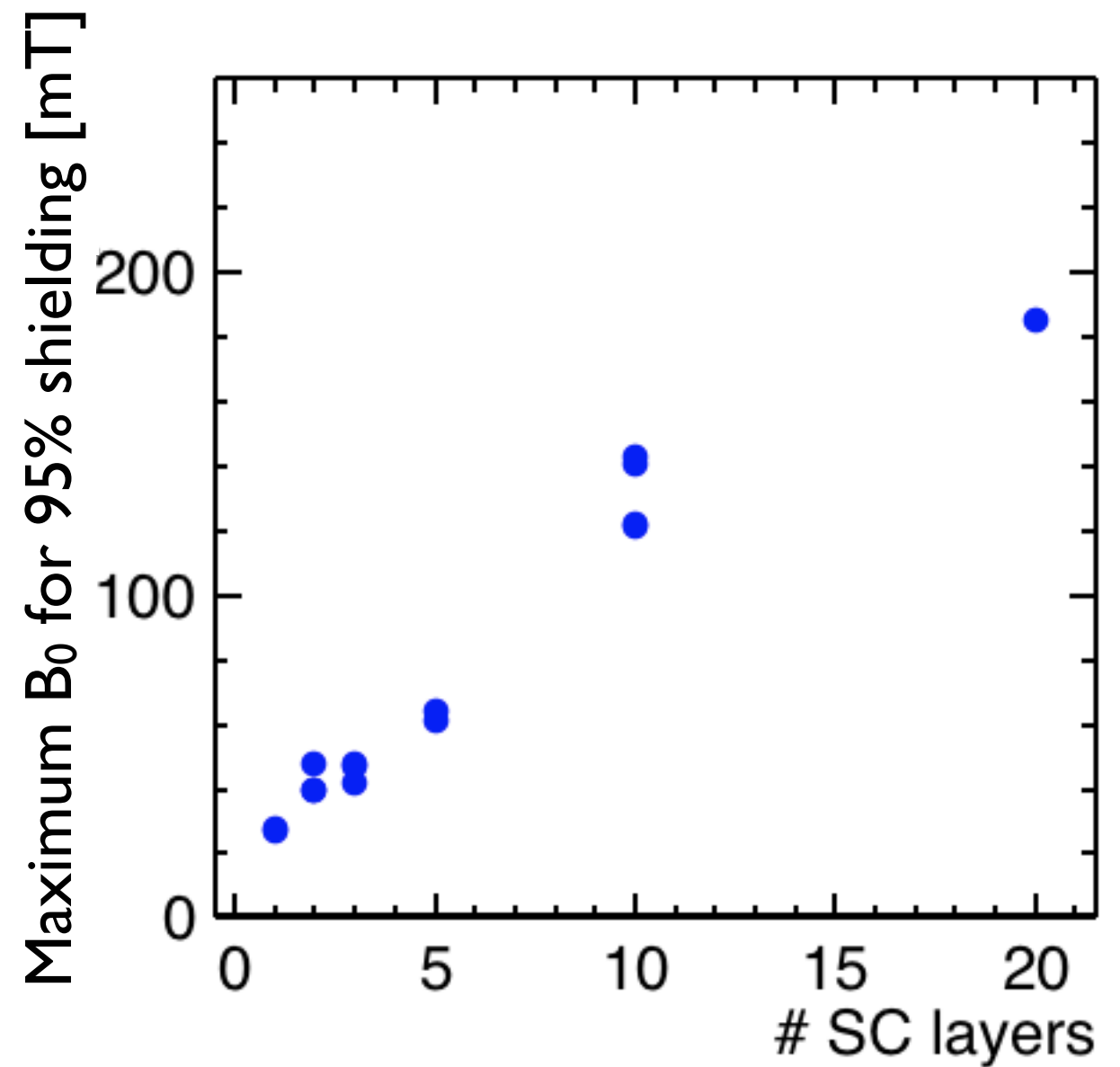
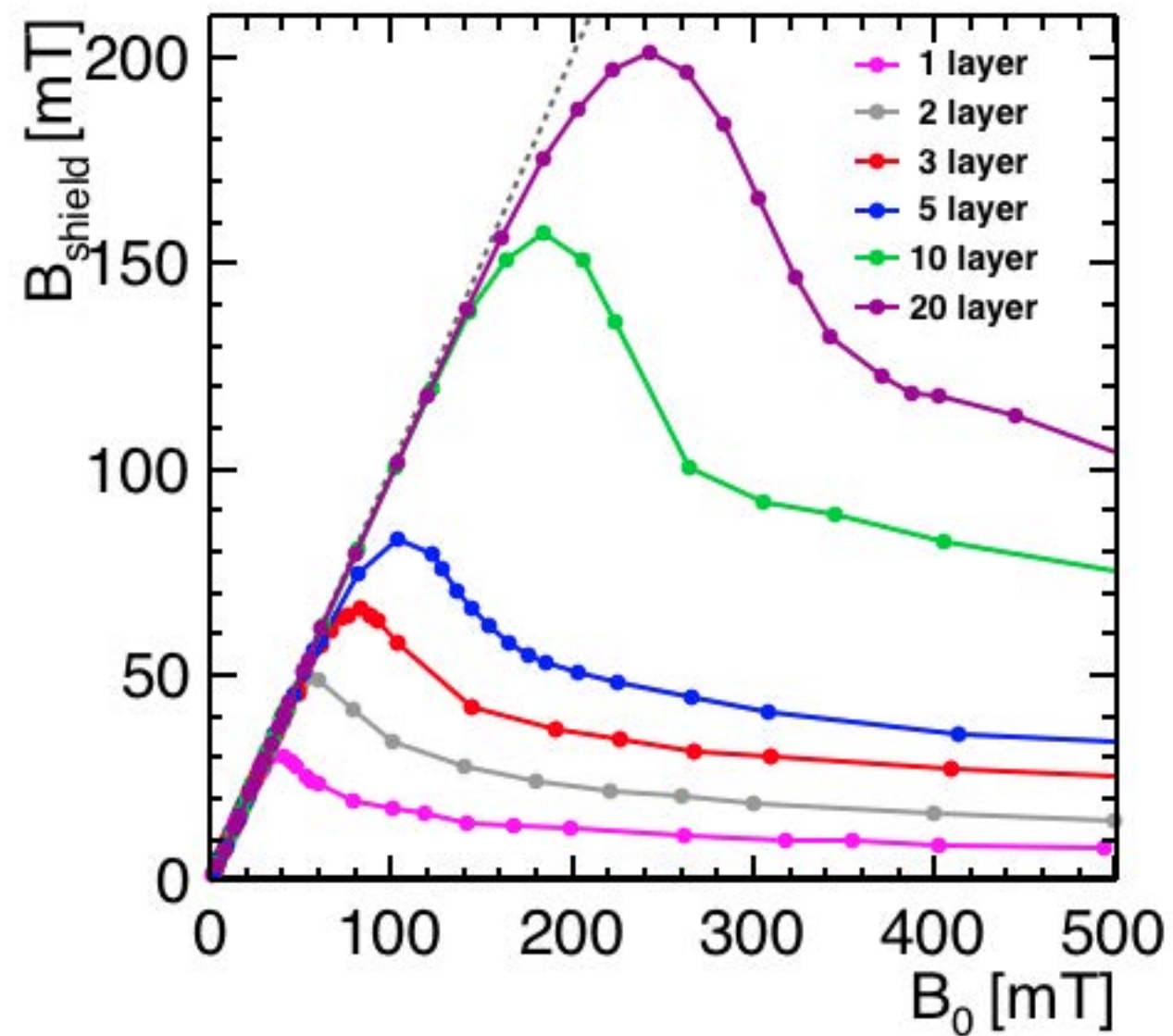
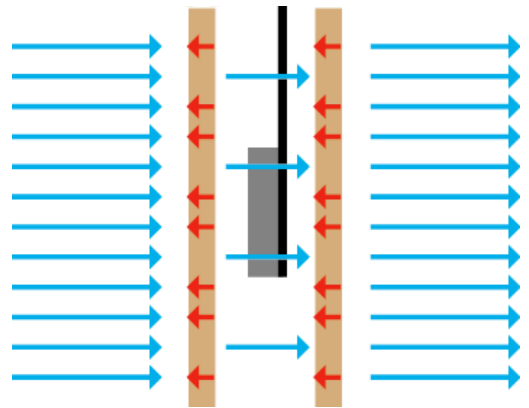


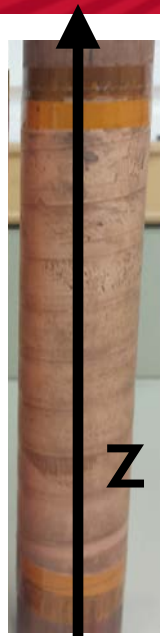


# Our HT Superconductor Tape

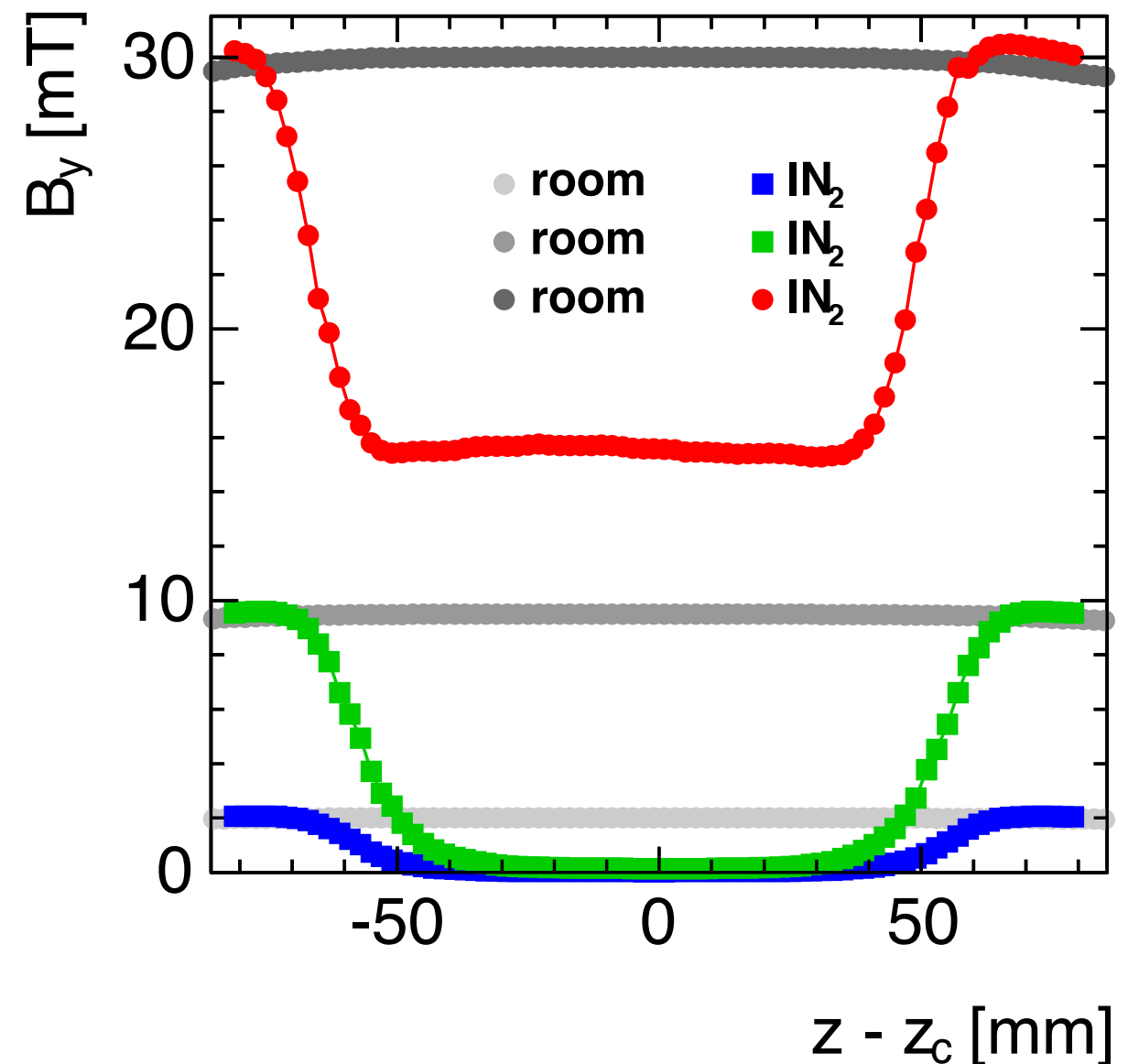
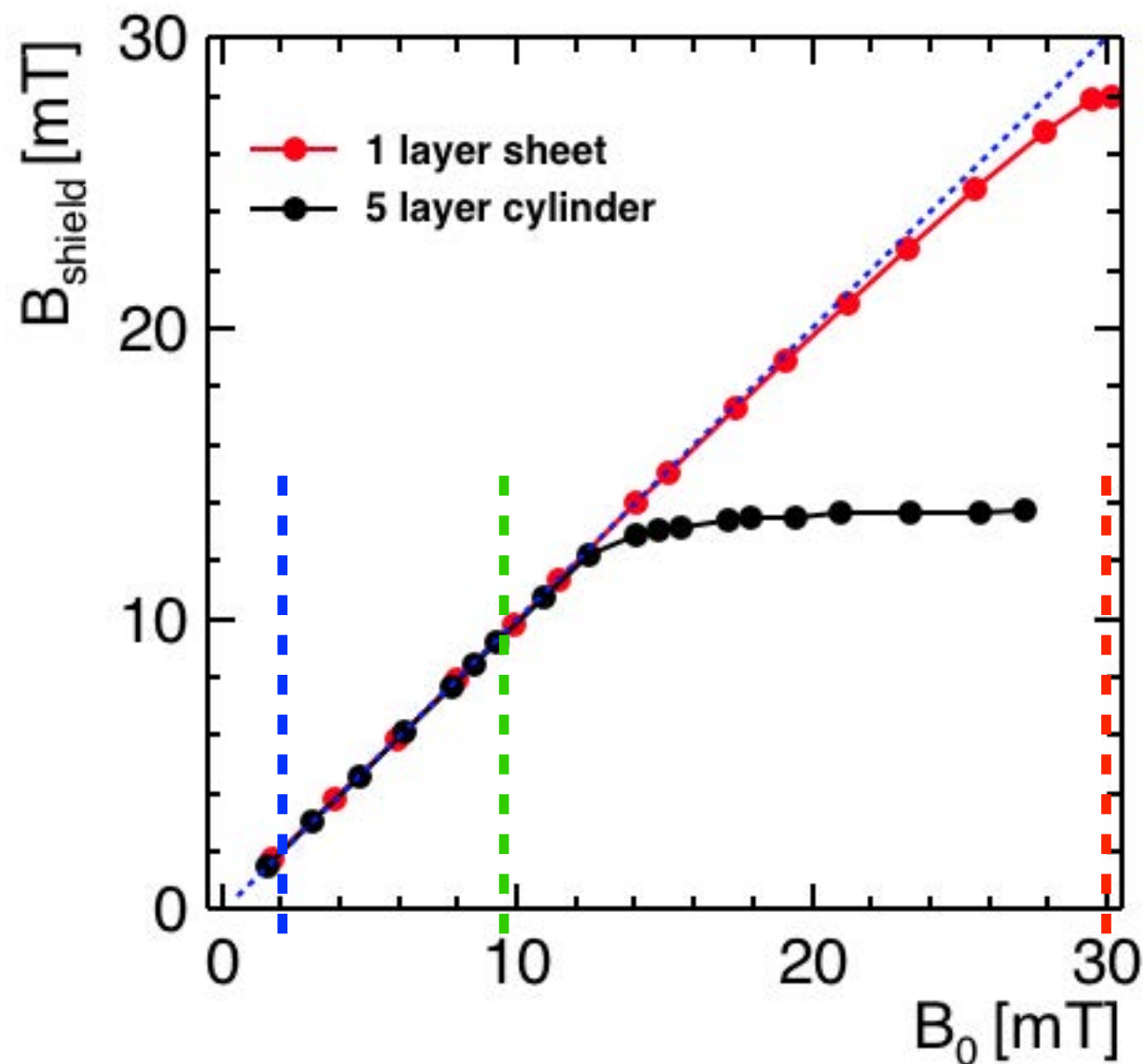


# Multiple Superconductor Layers Improve Shielding

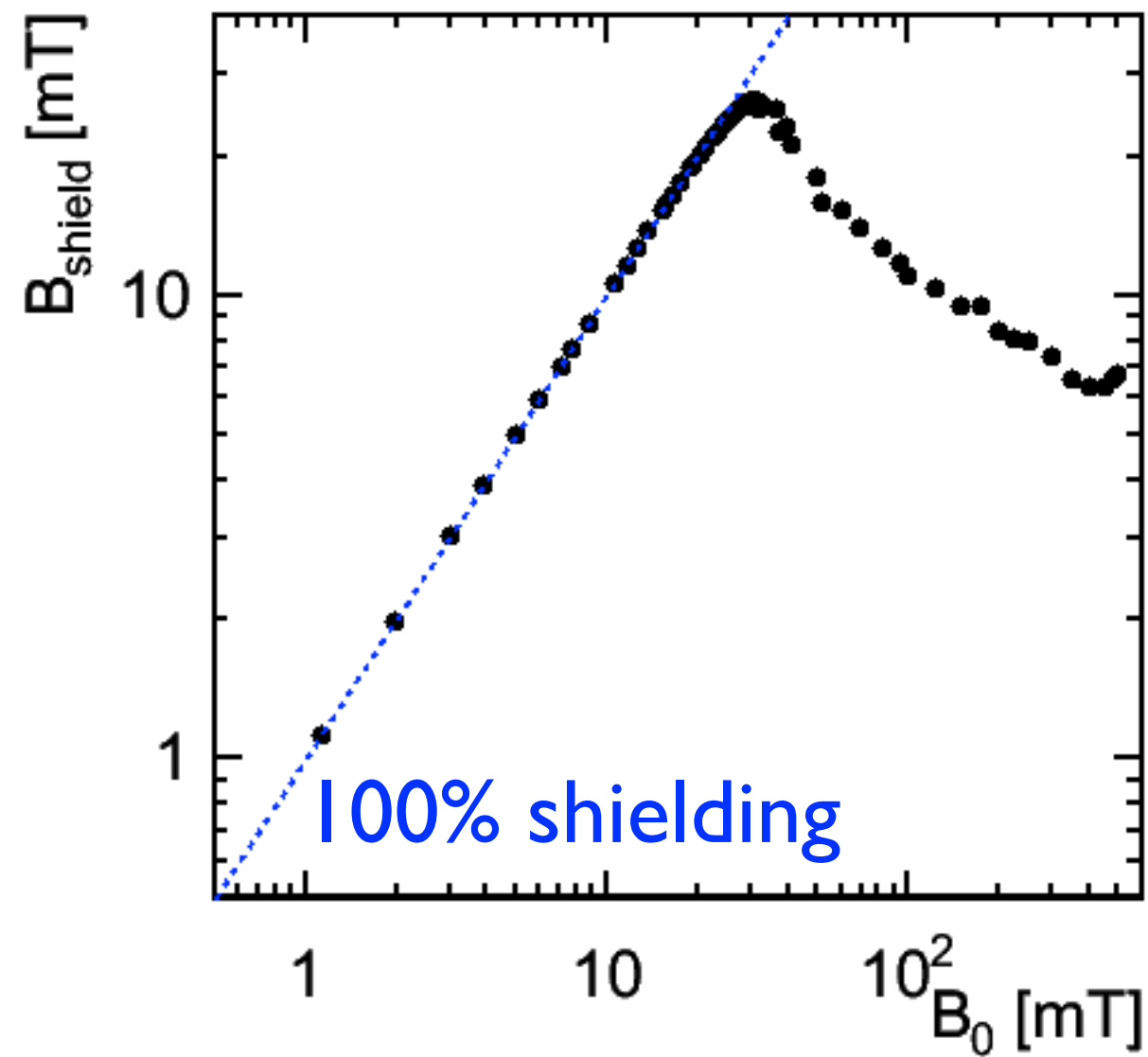




# Shielding Performance of a 12 cm Cylinder (5 Layer Helix)

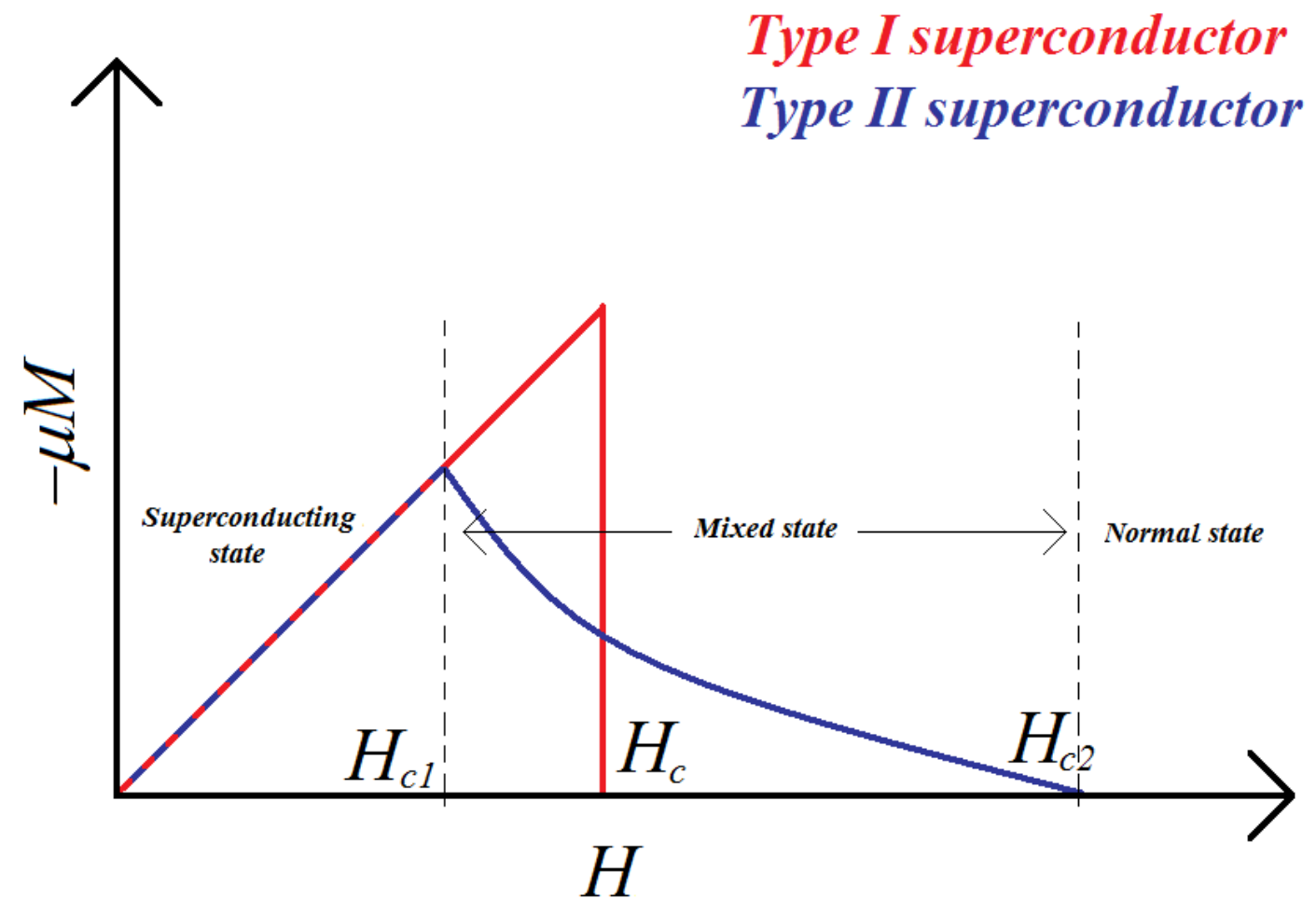


# SC tape performance at high fields



$B_{C1} \sim 20$  mT

$B_{C2} > 500$  mT





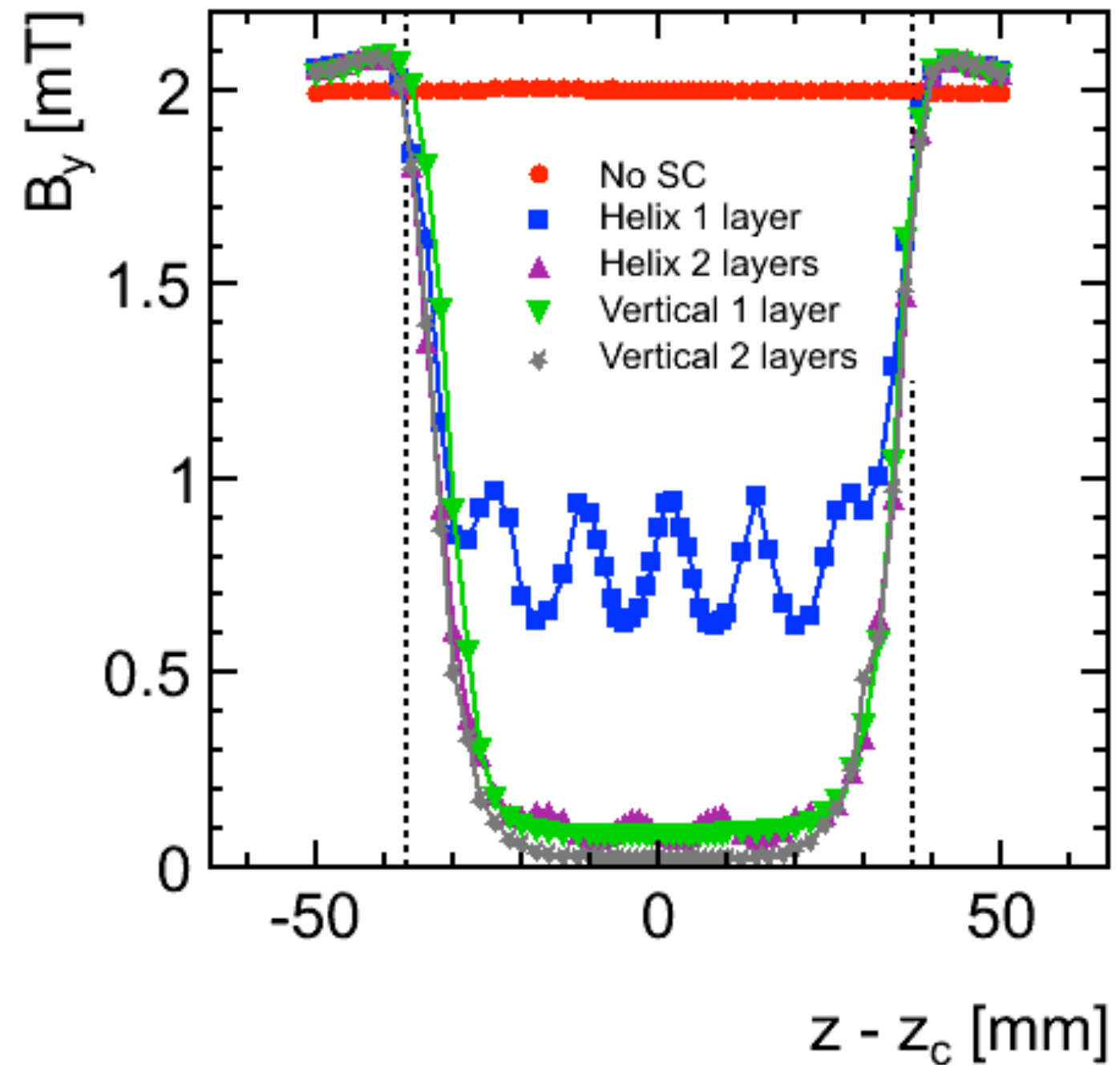
# Superconductor wrapping options



‘helix’

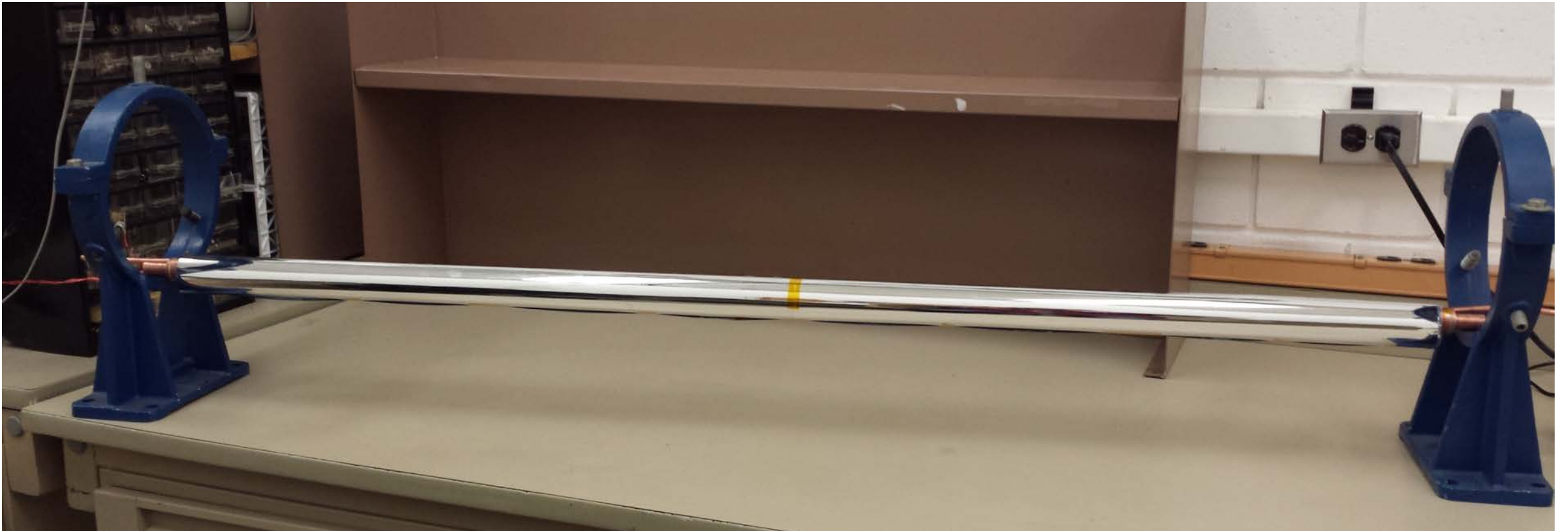


‘vertical’





# Heat Radiation Shielding



Six layers of Multi-Layer Insulation (alternating layers of aluminized Mylar and plastic foil)

# Beam-line Bending Magnet

